CAMT 11-4

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CANADIAN ARMY

MANUAL OF TRAINING

RECOVERY TECHNIQUE

(1962)

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PREFACE

The aim of this manual is to describe the technique used in carrying out recovery tasks, the difficulties that may be encountered, and the equipment employed. It is intended to fulfill the need for a general reference book on the subject. It contains information in suitable form for use by all arms when faced with recovery problems and by RCEME officers, WOs, NCOs and recovery crews in particular.

The introduction into the army of new types of equipment, particularly those of increased size and weight, may result in changes in design of recovery vehicles and equipment and may also lead to the use of new techniques. The principles and the methods described in this manual have been learned and proved by experience and will, if they are applied intelligently, provide the answer to most recovery problems.

This manual deals mainly with the recovery of tracked and wheeled vehicles and of equipment mounted in them. It does not cover repository work on static weapons, the installation or removal of heavy plant, the clearing of wrecked bridges, road or rail blocks and demolished structures. However, many of the principles and methods described can readily be applied to such tasks.

This manual is one of a series of RCEME training manuals. The series will comprise the following:

a. CAMT 11-1 RCEME in Canada
b. CAMT 11-2 RCEME in the Field
c. CAMT 11-3 Command of a RCEME Field Unit
d. CAMT 11-4 Recovery Technique

RECOVERY TECHNIQUE

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ABBREVIATIONS

BHP	Brake Horsepower
BR	Beyond Repair
CO2	Carbon Dioxide
CTC	Carbon Tetrachloride
ECP	Equipment Collecting Point
IHP	Indicated Horsepower
rpm	Revolutions per Minute
UAS	Unit Aid Station
X	A Casualty Which Requires Unit Repair
Y	A Casualty Which Requires Field Repair
Z	A Casualty Which Requires Base Repair

See also Staff Duties in the Field, 1949 (WO Code No 8457) Appendix "C" Canadian Edition 1959 Abbreviations.

CHAPTER 1

THE RECOVERY SYSTEM

SECTION 1 - INTRODUCTION

101. DEFINITION OF RECOVERY

a. Recovery covers a wide variety of tasks, ranging from locating and refuelling a vehicle that has gone astray and run out of fuel to extricating and removing a disabled tracked vehicle under enemy fire or clearing equipment casualties from a battlefield.

b. In its broader sense recovery also includes backloading and evacuation.

102. THE IMPORTANCE OF RECOVERY

a. The recovery of disabled equipment is one of the main contributions to the RCEME aim of ensuring at all times the operational fitness of the electrical and mechanical equipment of the army.

b. Speedy and efficient recovery means that an equipment casualty can be repaired and returned to troops with minimum delay. It can also deny the use of such equipment to the enemy. Very often it may prevent equipment casualties from deteriorating further owing to lack of care and attention.

c. Recovery resources are of special importance when used to keep roads, bridges and defiles clear for the tactical movement of troops. When so employed their efficiency may have a direct effect on the success of an operation.

SECTION 2 - FACTORS AFFECTING EFFICIÈNCY

103. GENERAL

Efficient recovery, especially in war, depends on observing certain basic principles. These are set out in CAMT 11-2 RCEME in the Field. The following paragraphs describe the application of some of these principles

to the particular task of recovery and some additional basic factors that must always be kept in mind by recovery personnel.

104. CO-ORDINATION

Although individual recovery tasks can usually be defined clearly, the employment of recovery resources as a whole, within a formation or area and even within a major unit, requires careful co-ordination if the necessary facilities are to be available at the right place and time. The responsibility for recovery in a brigade group, division or corps and sometimes a particular area is therefore usually allotted to an individual officer who exercises control over the bulk of the recovery resources in the formation or area.

105. FORESIGHT

a. Foresight, based on up-to-date information, is the key to successful recovery planning. In addition to keeping himself in the tactical picture a recovery officer requires early information of equipment casualties. In order to obtain this information there must be:

(1) close liaison with the staff of the formation being supported;

(2) a sound system for reporting equipment casualties;

(3) good communications.

b. Foresight also implies the use of imaginative thought based on experience and common sense so that resources are correctly deployed in anticipation of events.

106. FLEXIBILITY

a. No two recovery tasks are ever exactly alike. Techniques used must be capable of competing with the unusual and the unexpected. The organization of recovery must always be flexible and the division of recovery resources into first, second, third and fourth lines must never be regarded as being rigid or be allowed to restrict their employment in the way that best serves the

needs of the moment.

b. Officers and NCOs working on recovery tasks also require the flexibility of mind that will enable them to adapt the basic methods in which they have been trained to meet the requirements of any particular recovery problem.

107. PROTECTION AND CO-OPERATION

a. Although recovery crews are normally responsible for their own local defence against air or ground attack, an individual cannot carry out his technical task and fight at the same time. It may therefore be necessary, particularly during recovery in forward areas threatened by the enemy, to ask other arms to supply personnel for protection. In such circumstances the closest co-operation is necessary in order that recovery work may be speedily commenced and safely completed. In any event, before commencing work, it is always advisable for the officer or NCO in charge of a recovery crew to obtain information concerning local conditions, mines, etc from other troops in the vicinity.

b. On the other hand recovery crews are frequently in a position to give first information about events of local importance, such as details of damaged bridges or roads, crashed aircraft or wounded troops that they may encounter on the way to or from their task. They should use initiative in passing such information to a local unit or report centre and must always include it when reporting back to their HQ.

108. LEADERSHIP AND MORALE

a. Recovery, perhaps more than any other RCEME activity, depends upon the ability of the junior leader. Experience has proved that, under good leadership, recovery crews quickly develop an exceptionally high standard of initiative and self-confidence. Every effort must be made to foster these qualities which depend so largely on good morale.

b. The morale of a detachment is closely affected by the arrangements made for its control and administration. This is particularly true when it is separated from its normal channels of supply. Sound administrative arrangements are essential and there must never be any doubt as to the correct source of supply for rations, POL and any technical stores or spares that may be required.

SECTION 3 - THE BASIC RECOVERY SYSTEM

109. The basic system of recovery in the field is organized into four stages or lines. The forward movement of recovery vehicles to extricate equipment casualties and subsequently remove them to the rear is the main object of each successive line of recovery. The system is kept flexible, however, and a third line recovery unit may well be used to supplement second or even first line recovery resources if circumstances require it.

110. The scope of the four lines of recovery is detailed in CAMT 11-2, RCEME in the Field, Chapter 3.

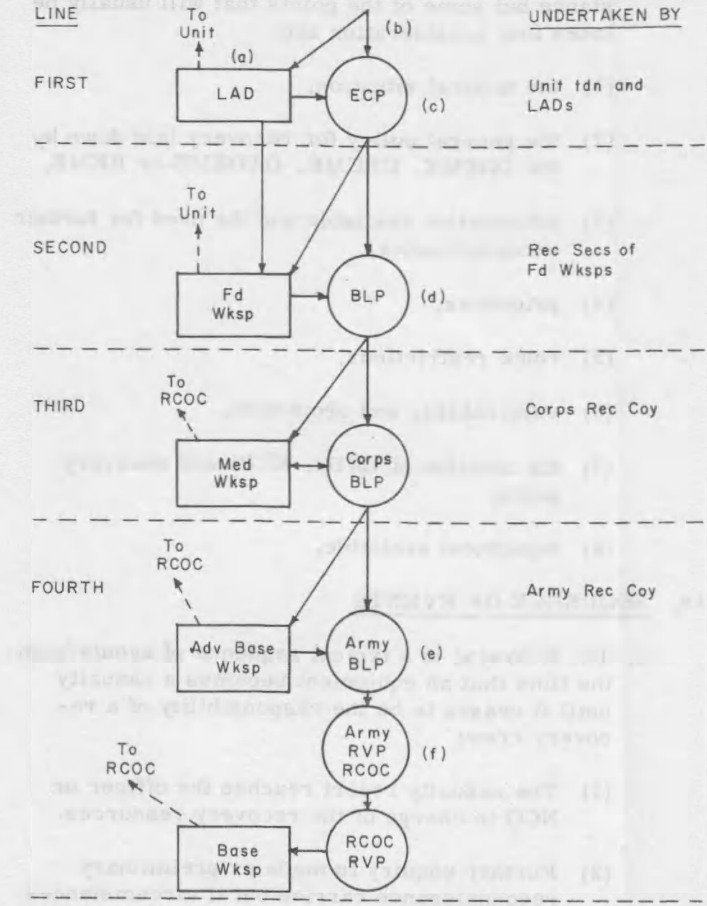
111. This recovery system covers the recovery requirements of the whole theatre between forward and base units. The system is illustrated in Figure 1.

112. The techniques in this pamphlet are mainly applicable to the extrication stage of first line recovery. It is most important however, that all recovery personnel whether employed in first or fourth line units should be trained in these techniques. Only through such all-round knowledge can resources become truly flexible.

SECTION 4 - PLANNING AND PROCEDURE

113. PLANNING

a. The planning and control of recovery at formation level are outside the scope of this pamphlet but some form of appreciation and planning is always necessary before a recovery crew can be given clear orders about its task. Action is usually preceded by the initiation and despatch of a casualty report and a preliminary reconnaissance may be required.



NOTES

(a) Repaired eqpts - - - →

(b) Eqpt cas →

(c) ECP - Equipment collecting point - manned by brigade group RCEME personnel.

(d) BLP - Backloading point - manned by field workshop personnel.

(e) Casualties transported by road or rail via army and base roadheads (RDHs) and railheads (RHs) from army BLP rearward.

(f) RVP - Returned vehicle park.

Figure 1 - Recovery in the Field

b. The factors to be considered will vary in each instance but some of the points that will usually be taken into consideration are:

(1) the tactical situation,

(2) the general policy for recovery laid down by the DDEME, CREME, DADEME or BEME,

(3) information available and the need for further reconnaissance,

(4) priorities,

(5) route restrictions,

(6) vulnerability and protection,

(7) the location of LADs, ECPs and recovery posts,

(8) equipment available.

114. SEQUENCE OF EVENTS

a. The following is a typical sequence of events from the time that an equipment becomes a casualty until it ceases to be the responsibility of a recovery crew:

(1) The casualty report reaches the officer or NCO in charge of the recovery resources.

(2) Further enquiry is made or preliminary reconnaissance carried out if circumstances require.

(3) An appreciation is made, the plan decided and the recovery crew briefed.

(4) The recovery crew goes to the casualty site and makes any necessary arrangements for local defence.

(5) The recovery crew reports the result of its work to its headquarters so that any necessary follow-up action can be taken. The

parent unit of the casualty is informed and records and returns are brought up to date.

115. REPORTING EQUIPMENT CASUALTIES

a. Recovery crews require certain information before they start out on a task. It is a unit responsibility to provide this information, therefore all unit personnel should be instructed on the correct method of preparation and transmission of a casualty report. RCEME personnel must be prepared to give advice and assistance in the preparation of casualty reports and the report should be passed to an LAD or a recovery facility for action.

b. The information must be limited to essentials, especially if the report is to be passed by radio. The following information should always be included:

(1) unit,

(2) type and make of equipment,

(3) army registered number,

(4) condition classification, eg X, Y, Z,

(5) brief description of the damage and whether suspended or direct tow is required or if casualty can move under its own power,

(6) accurate location, eg, six-figure grid reference,

(7) extent of assistance required,

(8) details of the location, ie, approaches, minefield, if under observation, etc,

(9) whether crew or driver is with the equipment.

c. Casualty reports will usually be sent by one or more of the following means:

(1) radio,

(2) signal message by means other than radio,

(3) written report,

(4) verbal message.

d. If no signal communications are available near the casualty site, it may be possible to stop a passing vehicle and give the driver a written message for delivery to the nearest recovery post. This is preferable to sending a verbal message which may be passed inaccurately.

e. The use of signal communications is further described in Chapter 2, Section 9.

SECTION 5 - SPECIAL RECOVERY TASKS

116. RESOURCES

a. In addition to their normal task of day-to-day recovery during operations, recovery resources may also be allocated for certain specific purposes, such as:

(1) route clearance,

(2) assisting unit moves,

(3) duty at demolition guards, bridging sites, etc,

(4) battlefield clearance.

117. ROUTE CLEARANCE

a. During moves of formations and other large bodies of troops it is essential to keep routes clear of obstruction so that traffic may flow steadily. Recovery resources are frequently detailed for this purpose, in which event they work under orders of the traffic control organization in charge of the move.

b. The normal method employed is to establish recovery posts at important road junctions, bridges, defiles and other potential bottlenecks, while road

patrols may also be detailed to operate over sections of main traffic routes. Their primary role is to maintain an uninterrupted flow of traffic in the sector or locality for which they are responsible. The initial recovery of casualties should be limited to clearing the route. Subsequently, during a lull in movement, the casualties may be collected at suitable points or taken forward to the new location.

c. An important part of the recovery task in these circumstances is to keep records of all vehicles recovered for the information of traffic control.

118. UNIT MOVES

a. A unit on the move is responsible for the recovery of its own vehicle casualties unless other arrangements have been made by the formation headquarters. The only resources available are usually the recovery vehicles of the unit or its LAD.

b. The recovery task in these circumstances has two main functions, ie route clearance and to see that every vehicle of the unit arrives at the new location. When breakdowns occur, therefore, the maximum use of towing facilities must be made throughout the unit column, the recovery vehicles being kept free to deal with emergencies or to convey casualties that require a suspended tow. Casualties that cannot be towed or quickly repaired must be moved clear of the route and left in charge of the driver or crew. A record will be made of all such casualties and their locations so that action may be taken to deal with them as soon as the move is completed.

119. RECOVERY DUTIES AT DEMOLITION GUARDS, BRIDGING SITES, ETC

a. Recovery teams may be detached for special duty with a demolition guard, at a bridging or fording site or in connection with operations for crossing a river or minefield. It is usual for such detachments to be placed under direct command of the officer in charge of the guard, crossing or operations.

b. Recovery resources so allocated usually have a limited task from which they must not be diverted and the detachment commander is not as a rule left to act at his own discretion. He may expect to be given information and orders such as:

(1) sufficient outline of the operation to make his role clear;

(2) the siting of the detachment;

(3) disposal of vehicle and equipment casualties;

(4) administration and replenishment.

120. BATTLEFIELD CLEARANCE

The general role of recovery crews used for battlefield clearance is similar to that outlined in paragraph 119 except that there will not usually be the same degree of operational urgency. The resources available are generally placed under an officer, a sub-unit or a unit which co-ordinates the work.

CHAPTER 2

FACTORS AFFECTING RECOVERY IN THE FIELD

SECTION 1 - GENERAL

201. In addition to good organization, the provision of up-to-date information on the tactical situation and the use of sound techniques improves the efficiency of recovery in the field. Efficient recovery is dependent on a number of non-technical military factors. Among them are:

a. state of readiness,

b. topographical conditions,

c. road movement restrictions,

d. protection,

e. safety of men and equipment,

f. communications,

g. administration.

202. The purpose of this chapter is to describe some of the most important of these factors, which have a considerable affect on the successful use of recovery techniques.

SECTION 2 - STATE OF READINESS

203. EQUIPMENT

a. Once a recovery task has been planned, speed in execution is of first importance. Vehicles and equipment must therefore be kept in a state of readiness for immediate use.

b. Officers and NCOs in charge of detachments must arrange for regular checks, inspections and repair of equipment. In particular they must do everything possible to ensure:

(1) serviceability of ropes, winches, shackles, snatch blocks, overall chains, tensioning devices, etc (the care and inspection of recovery equipment is the subject of Chapter 14);

(2) the good condition of all ancilliary stores including weapons, camouflage nets, shelters, firefighting equipment, cookers, hand-lamps, welding equipment, etc;

(3) roadworthiness of vehicles and accessibility and good condition of tools and equipment including recovery signs.

204. POL, RATIONS AND COOKING

a. Recovery crews should be self-supporting for at least three days. They must always start out with full fuel tanks and carry a reserve of POL, water and ammunition. They must also carry field cooking equipment and be trained to cook for themselves.

b. In addition to their own rations and water, detachments should carry a reserve for assisting stranded vehicle crews or stragglers.

205. RECOVERY CREWS

As crews may be required to turn out at any time of the day or night, some of them must always be held in a state of readiness. A system of rotation of duties is essential so that men have regular times allocated for servicing vehicles and checking stores and other periods during which they are free to sleep, clean up and relax. Rest and interior economy are important during operations.

206. OTHER REQUIREMENTS

a. The following additional points require checking before a recovery team is sent out:

(1) Detachments must hold a set of maps covering the area in which they are liable to work.

(2) If detailed to work in areas where mines or booby traps may be encountered, detachments

must be equipped with mine detectors and trained in the technique for clearing mines and neutralizing booby traps.

(3) Detachments equipped with radio must have trained operators familiar with the procedure for joining a working net. They must also be provided with a current list of call signs and be practised in the use of field codes.

(4) Tank crews must be experienced in emergency repair techniques and the use of welding plants or explosives for cutting or shortening the tracks of tanks, as described in Annex G.

b. Recovery crews should also be trained in and capable of performing the following tasks:

(1) radiation monitoring and decontamination,

(2) burial of dead and disposal of effects,

(3) making weapons safe,

(4) first aid,

(5) destruction of equipment,

(6) recovery work at night.

SECTION 3 - TOPOGRAPHICAL INFORMATION

207. INFORMATION REQUIRED

a. The topographical information necessary for directing a recovery crew to its task varies considerably. Very often only an accurate grid reference is required but when recovering equipment casualties in an unfamiliar area or in a locality threatened by the enemy, more detailed information must be given to a crew before it is sent out. Generally, some or all of the following points may have to be investigated:

(1) the best approach and return routes, including particulars of gradients, bridges, built-up areas, defiles, etc;

(2) the nature of the ground in which the casualty is situated;

(3) facilities for concealment and cover from the air;

(4) communications.

208. SOURCES OF INFORMATION

The particulars normally included in casualty reports have been described in Chapter 1, Section 4. If this information, supplemented by further details obtained from other sources or by map reading, is insufficient in any essential item it may be necessary to make a reconnaissance by motorcycle, truck or helicopter before despatching the recovery crew.

209. MAP READING

a. Much of the information necessary for planning can be obtained from a map. All recovery personnel and in particular those who may be placed in charge of a vehicle or appointed to drive, must be thoroughly trained in map reading.

b. In addition to being able to visualize the country from a map and to interpret contours and conventional signs, they must be able to find their way by day and particularly by night, sometimes over a network of minor roads and tracks, to a location for which they have only been given the grid reference. To do this they must know how to read the detail accurately from a small scale map and how to use a speedometer for measuring distances.

c. Training in map reading should be supplemented by instruction in other subjects which may help a man to find his way about a formation area. A thorough knowledge of the system of signing used in the army is often of much value in getting a detachment to the right destination. All recovery personnel should therefore be instructed in such matters as:

(1) army organization,

(2) the numbering and colouring of vehicle unit signs,

(3) the marking of formation axes,

(4) the signs for supply points, petrol points, water points, unit aid stations, signal offices, medical and provost installations.

(5) bridge classifications.

210. NAVIGATION

a. During operations in open country, with few roads or tracks, the only way of finding a particular location may be by dead reckoning, ie direction and distance from some known reference point. This is particularly important in aircraft recovery. To use this method with accuracy and confidence requires training and experience in making a compass traverse.

b. Recovery personnel should be taught the use of the prismatic compass for taking bearings and its disadvantages and limitations when in the vicinity of a vehicle. In appropriate theatres they may also have to learn how to navigate by sun compass which has particular value in featureless areas.

SECTION 4 - MOVEMENT BY ROAD

211. GENERAL

a. Recovery vehicles are liable to interfere with road traffic especially when towing or transporting crocks. They are bulky, combersome, easily recognized from the air and if rendered immobile they may block roads for long periods. For this reason their movement requires careful consideration and is often restricted to certain routes or times so as to avoid interference with operational traffic.

b. The following restrictions may also be imposed during operations:

(1) All major movements of recovery vehicles on main routes in brigade group or corps areas must have the prior approval of the

formation headquarters.

(2) During the move of a large body of troops the route must not be blocked by recovery operations without the authority of the traffic control organization in charge of the move.

c. The drivers and crews of recovery vehicles and transporters can do a great deal to reduce the delay and inconvenience that they inevitably cause to other road users. They must do their best to avoid holding up traffic and must display an exemplary standard of road courtesy.

d. Whenever possible, large recovery vehicles should be escorted by motor cyclists trained in traffic duties.

212. SELECTION OF ROUTES

Apart from any restrictions imposed by traffic control or other authority, the movement of recovery vehicles, owing to their size and weight, can be seriously affected by road conditions. Sharp bends, gradients and above all bridges provide difficulties that call for careful selection of routes by those despatching recovery crews to their tasks. Moreover, vehicle drivers and crews have a personal responsibility in this matter and are responsible that they do not damage a bridge or render a good road unusable by thoughtless conduct or by taking chances.

213. CLASSIFICATION AND PRIORITY OF TRAFFIC

a. The road traffic in forward areas may be considered in four categories:

(1) Operational Traffic. Armoured fighting vehicles, armoured personnel carriers and "F" echelon vehicles.

(2) Maintenance Traffic. Unit or RCASC vehicles, usually moving in groups or columns up and down formation axes by day or night, either on regular programmes or to meet a specific requirement, eg a dumping programme.

(3) Point To Point Traffic. Large groups of unit or formation vehicles moving from one locality to another in accordance with an operational plan.

(4) Casual Traffic. Individual vehicles or small groups moving independently within the area.

b. Most recovery vehicles engaged on individual tasks come under the heading of casual traffic which, except in emergency, may be required to give way to any of the other three categories.

214. IDENTIFICATION OF RECOVERY VEHICLES

a. Every recovery vehicle must be equipped with a standard sign so that it may be identified by day or by night and be able to secure right of way in an emergency.

b. The sign, which consists of the word RECOVERY in six-inch red letters on a white background, may only be displayed when the vehicle is actually being used on a recovery task.

215. ROAD AND BRIDGE CLASSIFICATION

a. The RCE are responsible for the classification of routes and bridges in the operational areas and for the erection of classification signs.

b. The classification numbers show the maximum load class that the bridge will carry. They are marked on circular signs of not less than 16 inches in diameter which have black figures printed on a yellow background. Particulars of classification will be found in Appendix B and O to CAMT 10-3, Traffic Control 1956 and Annex 2 to the Manual of Vehicle Markings.

c. The classification of main routes in a formation area is usually notified in orders and is also indicated by signs erected at important road junctions and other suitable positions. Road and bridge classification maps are sometimes issued and should be used when available.

216. VEHICLE CLASSIFICATION SIGNS

Vehicles and trailers are classified to indicate the equivalent loads they will impose on a bridge. Vehicle

classifications are listed in the Canadian Army Manual of Vehicle Markings - Annex 2.

SECTION 5 - PROTECTION AND CONCEALMENT

217. GENERAL

a. Except when arrangements are made for protection by other arms, recovery detachments are responsible for their own local defence. During extensive recovery operations in forward areas a co-ordinated defence plan will often be made, leaving recovery crews free to get on with their tasks.

b. Frequently the only defensive measures necessary are the provision of an air sentry and the concealment of activity, as far as possible, from the air. Precautions may sometimes have to be taken against mines or booby traps and there will be occasions when the tactical situation is fluid or uncertain and further precautions must be taken.

218. PRELIMINARY RECONNAISSANCE

If there is any doubt about the situation in the vicinity of an equipment casualty the recovery vehicles should be halted under cover nearby and a reconnaissance carried out by the officer or NCO in charge. Both tactical and technical considerations should be borne in mind and the ground studied carefully to decide upon the most likely approaches for enemy patrols and whether concealment from the air is possible. Other troops in the vicinity should be requested to assist if necessary. The technical appreciation should be made at the same time as the tactical reconnaissance so that vehicles can be placed in position quickly, with a minimum disturbance of the ground, as soon as the plan is put into operation.

219. MINES AND BOOBY TRAPS

All recovery crews must be trained to locate and clear mines. If a crock is lying in a mined area the detachment must be given all available information and must be provided with mine detectors before setting out. Moreover, if there is any likelihood of the enemy having tampered with the casualty, a careful examination of the area for booby traps will be necessary and special precautions will have to be taken throughout the operation.

220. CONCEALMENT AND CAMOUFLAGE

a. There is no basic difference in the precautions taken to conceal a recovery operation and those necessary for the concealment of any other military activity. Dispersion, discipline, intelligent siting of vehicles and the correct use of camouflage are the main requirements. All detachments must be familiar with the technique of using camouflage nets and other devices to break up the outline of vehicles as viewed from ground level or from above. Instruction in this technique is contained in CAMT 2-70, Visual Training, Observation and Concealment (All Arms) 1957.

b. The following paragraphs deal with the particular problems of concealing the activity of recovery crews.

c. The problem is complicated by the fact that some movement is inevitable during a recovery operation and that its detection may render useless the most successful camouflage of stationary vehicles and equipment. Concealment of recovery therefore has to be considered from the point of view of two requirements - firstly to disguise vehicles and equipment and secondly to conceal movement and its traces throughout the recovery operation.

d. The first requirement presents no unusual problems except that, owing to the location of an equipment casualty, it will often be impracticable to make use of natural cover during the process of extrication. The best possible use must therefore be made of camouflage nets and screen garnished with the most suitable material available.

e. Concealment of movement is far more difficult but the chances of detection may be reduced by attention to the following points:

(1) speed - if the job can be done quickly, elaborate concealment measures may be unnecessary;

(2) careful disposal and concealment of spoil from digging;

(3) provision of hessian windscreen blinds and elimination of reflection from bright equipment;

(4) full use of camouflage nets and screens to conceal vehicles and equipment around which movement cannot be avoided;

(5) careful preliminary reconnaissance so that vehicles can be placed in position quickly with the minimum of movement;

(6) alert air sentries and immediate cessation of movement if an alarm is given;

(7) screening lights and welding arcs;

(8) concealment discipline, ensuring the minimum exposure of men and material, minimum noise, careful control of the use of flashlights, lamps etc.

221. LOCAL DEFENCE

a. A recovery crew has insufficient men for the conduct of elaborate defence schemes and except for a sentry or sentries the crew will be concentrating on the recovery task. At the same time plans must often be made to guard against a surprise attack.

b. The principles and methods of local defence, as described in the appropriate pamphlets on Infantry Training, must be known to detachment commanders who must be capable of applying them to any situation.

c. Any plan made must be simple. The essential elements are an adequate lookout and a distinct alarm signal or signals with every man briefed clearly on the action required from him when the alarm is given. Usually the crew will take up pre-arranged positions for the defence of the vehicles and, if equipped with radio, the commander will inform control of the situation.

d. If the air situation is adverse or if there is any risk of ground attack, it may be advisable to dig slit trenches before starting on the recovery task. The time factor will be the main consideration in this decision.

e. The following general points require attention during training;

(1) digging slit trenches and taking other precautions for protection against ground or air attack;

(2) care and disciplined use of respirators, gas and radiation detectors and other protective equipment that may be issued to the detachment;

(3) training the detachment to carry out their normal duties for long periods while wearing respirators or protective clothing;

(4) ensuring that there is a distinct alarm for each likely form of attack and that all ranks know what they have to do if the alarm is given;

(5) ensuring that all relevant information and instructions issued on the subject are passed on to the men.

SECTION 6 - SAFETY PRECAUTIONS

222. GENERAL

Apart from operational risks, there are many hazards common to every recovery task. One of the most important is the risk of fire which is considered in Section 7. Other possible causes of danger to men or damage to equipment and the best way to guard against them are described in the following paragraphs.

223. SAFETY OF PERSONNEL

a. Recovery work is arduous and often calls for considerable physical effort and an element of danger may also be present. While parade ground precision of movement is not expected, detachments

must always work as a disciplined team under the orders of a leader if accidents are to be avoided. A recovery operation should be carried out as a drill in which everyone knows what he has to do and what to avoid. Men must keep to their allotted positions and remain alert for instructions by voice or signal. Cross-talk and chatter must never be allowed. The standard system of signals described in Annex F must be known and understood by all ranks.

b. The team leader will ensure the rigid observance of certain basic safety rules. The following are the most important:

(1) A man will never be allowed to crawl under a jacked-up equipment or to work under it until full support has been provided by chocks.

(2) Careful precautions are necessary against heavy equipments slipping when jacks, tackles, cranes or similar means are being used to raise them. The capacity and efficiency of lifting gear, the strength of slings and the method of applying them and the alignment of a pull with the centre of gravity of the equipment must be checked before hoisting is allowed to commence.

(3) When lifting a heavy weight men must keep their legs together to avoid rupture and they must be prevented from attempting to move weights beyond their strengths. The experience of the leader is the best guide to the limit.

(4) Men must keep clear of ropes under load, especially wire ropes. If a wire rope has become fouled it must never be cleared by hand but by using a crowbar or other suitable lever.

(5) Screens or goggles must be used with electric welding plant to protect the eyes.

224. MATERIALS AND APPLIANCES

a. The rules described for ensuring the safety of men will also help to prevent overstrain and damage to equipment and appliances.

b. All equipment must be adequate for the work, in good condition and correctly applied. Most appliances are marked with the safe working load, a figure which allows a fair safety margin and this margin must never be reduced by overloading.

c. The following safety rules should be observed before applying a load to any lay-out:

(1) The calculations of the estimated load should be correct.

(2) All the material and equipment in use should be adequately proved by test or inspection.

(3) The equipment should be correctly applied to the task.

SECTION 7 - FIRE

225. FIRE PRECAUTIONS

a. The drivers and crews of recovery vehicles must be familiar with orders for the prevention of fire as detailed in the Canadian Army Manual for Drivers, Wheeled Vehicles and in any other instructions on fire precautions for tracked vehicles. The crews must also know the precautions necessary to prevent the outbreak of fires from the use of welding equipment.

b. The following precautionary rules are of particular importance and their observance should be so rigidly enforced that it becomes automatic:

(1) Smoking will not be allowed in vehicles loaded with fuel, ammunition or explosives.

(2) Engines will not be run during the loading or unloading of explosives.

(3) Tarpaulin covers and camouflage nets must be secured clear of the exhaust system, especially when a vehicle is on the move.

(4) Whenever it is necessary to drain or re-fill the fuel tank of a vehicle, no smoking, welding nor any naked flame will be permitted within a radius of 10 yards.

226. FIRE-FIGHTING

a. Unit Standing Orders for fire-fighting will detail the soldier's personal responsibility and action in the event of fire. Recovery personnel must in addition be ready and competent to deal with fires which may break out in equipment casualties or in their own recovery vehicles. The action taken to deal with fire will usually be:

(1) use any appliances and other means available to put it out;

(2) give the alarm;

(3) summon outside assistance if necessary and available;

(4) use every means to prevent the fire from spreading, such as the removal of other vehicles or inflammable material from the area.

227. FIRE-FIGHTING APPLIANCES

a. The fire-fighting equipment issued with vehicles ranges from the small CTC extinguishers (carbon tetrachloride), issued with cars, to the large CO^2 extinguishers (carbon dioxide) and methyl bromide containers installed in tracked vehicles. Some tracked vehicles have an automatic alarm system in which excessive temperature, indicating fire in the engine compartment, causes a horn to sound in the driver's compartment. Carbon dioxide can

then be released from suitably placed containers by a remote control in the driver's compartment.

b. Fire-extinguishers work on several different principles and recovery crews must be able to select the correct type for the sort of fire they are trying to extinguish, otherwise they may, by using the wrong appliances, do more harm than good. Knowledge of a few elementary facts will help to prevent such dangerous mistakes.

c. The main points to remember are:

(1) For burning PETROL, OIL, PAINT or similar material:

(a) FOAM is the best extinguisher.

(b) WATER should NOT be used except by trained firemen who know how to spray it on from special nozzles - water from buckets or normal nozzles may spread the flames.

(2) For fires originating from ORGANIC material such as WOOD, PAPER or RAGS:

(a) SODA AND ACID or FOAM may be used for this type of fire.

(b) WATER in any form may be used.

(3) For limited outbreak of fire within vehicles:

(a) use the extinguishers provided with the vehicle or others of a similar type;

(b) remember that gases from these extinguishers are poisonous and can cause suffocation.

(4) For fires of ELECTRICAL origin, such as might occur in a vehicle electrical system, the vehicle type of extinguisher is suitable as the liquid and gases produced are non-conductors of elect ricity.

SECTION 8 - MEDICAL

228. GENERAL

A recovery crew, especially in forward areas, may be the first to render assistance to a vehicle casualty. Crews must therefore be trained to render first aid to the injured and to dispose of the dead.

229. FIRST AID

a. All recovery vehicles carry first aid kits which should include morphia ready for use. Shell dressings are issued to the crews on a personal scale. As many men as possible should be given first aid training including:

(1) the immediate treatment of wounds and burns;

(2) the application of pressure bandages and splints;

(3) the use of morphia.

b. Crews must also be practised in the technique of removing casualties through the turret of the tank. Except in emergency, first aid should not be rendered to an injured man inside a tank.

230. EVACUATION OF CASUALTIES

a. Wounded, injured and gas casualties are evacuated to the nearest Unit Aid Station (UAS). In armoured units the UAS is usually found with A1 echelon or near regimental headquarters. Men who have been contaminated with gas but are not otherwise injured do not require medical attention and are responsible for their own personal decontamination.

b. Unless it is unavoidable, recovery vehicles should not be used for conveying casualties. They are unsuitable for the purpose and to use them may seriously delay recovery.

231. BURIAL PROCEDURE

a. In the absence of a unit representative who can deal with the matter, recovery crews are responsible for arranging for the burial of any dead found in tracked or other vehicles that they recover and for the disposal of their effects. On no account will human remains be left in a vehicle that is to be backloaded.

b. In operations the personal effects of the dead man will be removed. When two identity discs are on the body one only will be removed and the other left. Where there is only one identity disc it will on no account be removed from the body. The recovery commander must make a duplicate list of the effects retaining one and sending the other, together with the effects and the second identity disc if there is one, to his unit headquarters.

c. Normally the burial of the dead is the responsibility of the chaplains, assisted by the personnel of Unit Aid Stations, but in their absence the duty may fall to the recovery crew commander. He must therefore know how to carry out a burial, to conduct a burial service and to mark and record the site of a grave. It is most important that all graves are registered and marked with temporary crosses.

d. Similar registration and burial procedure must be observed with any enemy dead who may become the responsibility of the recovery crew.

SECTION 9 - INTERCOMMUNICATION

232. GENERAL

a. The communications required in different recovery tasks vary considerably but any recovery crew at any time may be in need of sufficient communication facilities to:

(1) pass information to or receive information or instructions from the next higher authority;

(2) ask for assistance should any unforeseen difficulties or requirements become evident.

b. Good communications may be a major factor affecting the speed of recovery. All detachments, especially those without their own radio sets, must be on the lookout for facilities which they may use should the need arise.

233. VERBAL MESSAGES

a. Verbal messages transmitted by runner, motorcyclist or telephone are liable to be passed on incorrectly.

b. The following simple rules will help to ensure that a verbal message is passed accurately to the person for whom it is intended and all recovery crews must know them:

(1) The message must be brief and in terms as simple as possible.

(2) The message carrier or the man at the other end of the telephone should be made to repeat the message back correctly.

(3) A verbal message should be addressed to an individual by his appointment rather than by name, eg to the CO 3 Field Workshop rather than to Major Bluebell.

(4) The time of origin of the message should be included.

234. WRITTEN MESSAGES

a. The message form, CAFB 1718, must always be used for a written message sent through signals. The rules for message writing are fully described in Staff Duties in the Field, Chapter 6 and CAMT 1-36 CAMSP Volume 1 Military Writing. The following points are especially important and must be known to all recovery personnel:

(1) Be as brief as possible consistent with being clear.

(2) Use block capitals for personal and place names, cardinal points of the compass, RIGHT and LEFT, and important words such as NO or NOT.

(3) A grid reference should follow the name or description of a place.

(4) Numbers should be written in full if there is likely to be any confusion.

235. RADIO

a. If a recovery vehicle is equipped with radio at least one of the crew must be a trained operator and it is also of great value if all of them know how to man the set and can send and receive messages accurately and securely.

b. Signal Training (All Arms) Pamphlet 7, Voice Procedure, 1955, will be used for training in voice procedure.

c. A good knowledge of operating and of the sets in use within a formation may enable a recovery crew without radio to make use of a set in an equipment casualty. To do this they must know the procedure for breaking in on a working net as well as the call signs and codes being used.

236. SECURITY

Many of the messages sent and received by recovery detachments are such as may disclose to the enemy the location or identity of an equipment casualty or even of a unit or formation. All personnel must be aware of this danger and trained in the correct use of current field and grid reference codes.

SECTION 10 - ADMINISTRATION

237. GENERAL

a. Administrative matters generally are outside the technical scope of this pamphlet. There are, however, a few points that require special consideration as recovery crews, sometimes commanded

by a junior NCO, may frequently have to work for several days in a place where the normal administrative and supervisory facilities provided by their parent unit are not available.

b. Some of the points were covered briefly in Section 2 when considering the state of readiness of detachments. Others are described in the following paragraphs.

238. DISCIPLINE

a. Discipline in a small detachment depends firstly on the personality and leadership of the commander and secondly on the military and technical proficiency of the crew to give them pride in their work and foster a high state of morale.

b. The degree of formal discipline will vary in different detachments but the essential control that prevents injury and damage is based on alertness, knowledge, interest and prompt obedience of orders.

239. GENERAL ADMINISTRATION

a. Some administrative matters such as leave, pay, mail and general welfare are the responsibility of the unit but detachment commanders must not hesitate to report any shortcomings or difficulties that affect the morale of their men.

b. On no account must detachments be left to fend for themselves in the provision of rations, water, POL or technical stores. They must always be given instructions as to the right source of supply. At the same time they must be prepared to look after themselves, for long periods, in such matters as cooking, hygiene, sanitation, care of arms and equipment, and the rendering of any casualty reports or recovery records that may be required.

240. ARMS AND AMMUNITION

a. The personal weapons of recovery crews may be rifles or SMGs and their units are equipped with LMGs. Their commanders allocate weapons to detachments to suit their probable needs, so each man

should be trained to use any of them. The normal weapon training of recovery personnel should also be extended to include the pistol and it is an advantage if they can handle other weapons in use in their formation.

b. If an LMG is carried, its care and servicing are made the responsibility of one of the crew while every other man looks after his own personal weapon and ammunition. The detachment commander will make regular inspections of arms and check the ammunition held.

241. CLOTHING AND EQUIPMENT

a. The scales of working clothes for recovery crews vary according to the weather conditions in which the crews travel. The essential requirement of working dress at any time is that it should be:

(1) comfortable and workmanlike,

(2) suitable for existing weather conditions,

(3) as uniform as possible.

b. Recovery can be an arduous and dirty job but the crew must always look as soldierly as working conditions permit.

c. The following are the normal types of clothing worn for recovery:

(1) The normal dress for crews of recovery vehicles is coveralls, boots and gloves.

(2) Clothing for inclement weather:

(a) A special scale of oilskin jackets, sou'westers and rubber knee boots may be issued to recovery crews.

(b) Parkas may be obtained on special demand for use in cold weather.

242. REST AND RECUPERATION

a. The usual routine for recovery crews comprises periods of intense activity alternating with intervals for rest and preparation. The main requirements on returning to base after completing a task are refuelling, checking and servicing vehicles and equipment and rest and recuperation for the crew.

b. The detachment commander must also see that his men do not get overtired while engaged on a long and especially difficult recovery task. Tired men get careless and may become a danger to themselves and others. He must use judgment in giving them a change of occupation. It may well be advisable to stop work altogether for a few hours so that they may all rest or sleep at the same time. The construction of simple shelters, using ponchos, should be taught in case vehicles are unsuitable for this purpose.

243. CASUALTY RETURNS AND RECORDS OF WORK

a. During operations all units are required to submit daily casualty returns. Recovery crews are responsible for providing information of any casualties in personnel they have suffered. The form of report, and the time by which it is required, is usually detailed in unit Standing Orders.

b. Detachments must also keep records, in a suitable notebook, of all recovery tasks that have been allocated to them as well as any others on which they have taken action. They must also report and record details of any casualties encountered on which they have not been able to take action.

c. A suitable form of record is illustrated in Figure 2:

SERIAL Nº	UNIT	CAR Nº	TYPE	RECOVERED		DATE	DETAILS AND CLASS (XYZ)
				FROM	TO		

Figure 2 - Record of Work to be kept by recovery crews

CHAPTER 3

TERRAIN

SECTION 1 - THE EFFECT OF TERRAIN ON RECOVERY TECHNIQUE

301. GENERAL

a. The effect on a recovery task of the terrain in which it has to be carried out may be considered under three main headings:

(1) The slope of the ground.

(2) Altitude.

(3) The nature and consistency of the soil.

b. The resistance to movement of an equipment casualty caused by slope is dealt with fully in Chapter 4, Section 6.

302. ALTITUDE

a. Recovery operations are affected by altitude in two ways. First, owing to the reduced oxygen content of the atmosphere at high altitudes, there is increased fatigue caused by physical effort. Secondly, the power developed by internal combustion engines falls off at high altitudes with the result that the maximum pull of vehicle or winches is correspondingly reduced although the effective weight of equipment casualties and their resistance to motion remains the same as at lower levels.

b. Allowance must be made for these two factors when a detachment is working at a height that has been found in practice to produce a noticeable effect either on personnel or on vehicle engines.

303. NATURE AND CONSISTENCY OF SOILS

a. The widely differing types of ground surface and their sub-soils have a considerable effect on the

effort required to extricate and move an equipment casualty and must be considered in deciding the technique to be employed.

b. A good knowledge of soils and their characteristics is therefore of great value in solving recovery problems. Unfortunately, much of this knowledge cannot be obtained from training manuals and has to be built up from practical experience.

c. There are, however, a number of facts about ground surfaces, soils and sub-soils that can be learned from books and knowledge of them will often save a recovery crew a great deal of time and trouble. Two items of particular value are:

(1) ability to recognize and identify different types of soil;

(2) knowing the main characteristics of the various soils, both in wet and dry weather and the probable effect on the recovery task.

304. RECOGNITION OF SOILS

a. As already stated, experience is a good guide and local knowledge is even better but failing these, the colour of soil and vegetation will often give a useful indication of the types of going to be expected in an area. The following rules are generally true though there are many exceptions:

(1) Light coloured soils indicate percolating water. The soils may be chalk, gravel or sand and unless they are badly broken will usually provide good going for vehicles. Sand dunes are obvious exceptions to the rule and so are certain types of sticky clay.

(2) Brown soils provide good going as a rule, except for ploughed land, but their suitability for vehicles varies with their dampness. Very dark brown soils in particular tend to be sticky and heavy when wet and often have a thin and treacherous surface crust.

(3) Red soils are uncertain. Those derived from sandstone or limestone usually provide good going, though dull red or purple clay soils are almost impassable when wet.

(4) Grey slate-coloured soils are typical of clay and have the characteristics described in Section 2. They provide good or very bad going according to their consistency and dampness.

(5) Black soil usually means trouble. It can indicate peat, boggy ground, or in certain countries, black cotton-soil. It should be avoided at any rate until a careful reconnaissance has been made.

(6) Bright green patches of grass or vegetation in an otherwise uniform tract usually give warning of soft spots that are to be avoided.

305. GOING MAPS

a. In theatres where roads are scarce or where the ground is generally available for cross-country movement, as in desert warfare, it is usual for the G staff to provide a series of going maps. These maps are suitably coloured or shaded to show areas where vehicles can safely travel over the surface and those where the ground is rocky, soft or otherwise unsuitable. They can be of considerable use in recovery planning and will show the best route to follow in approaching a casualty and sometimes give a useful indication of the probable nature and difficulty of a recovery task.

b. Their existence, however, in no way lessens the need for accurate casualty reports and for careful reconnaissance by recovery teams.

SECTION 2 - TYPES OF GROUND AND THEIR EFFECT ON RECOVERY WORK

306. GENERAL

a. Most areas will be found to have a sub-soil of indefinite depth covered by surface soil which in cultivated areas may be up to a foot in depth or even more. In barren places it may be considerably less while in hilly or mountainous country rocky outcrops may break through the surface soil.

b. The surface soil may be firm enough for vehicles to rest upon and this is so, for example, with turf and with firmly knit sand. When dealing with equipment casualties, however, the surface soil is usually found to be sheared or broken and the nature of the sub-soil then becomes of first importance, in particular its ability to withstand compressive and shear loads.

307. THE EFFECTS OF MOISTURE

In considering the resistance of different soils to the loads applied by wheels, tracks, holdfasts, etc during recovery operations there is one variable factor of major importance, ie the effect of moisture. Ground that is firm or even hard in dry weather may become soft, boggy or strongly holding after a period of rain or even after a heavy shower. Any theoretical knowledge of soils is therefore useless unless applied with the knowledge of the actual conditions on the spot and can never replace practical experience and a good eye for ground.

308. SUB-DIVISION INTO CATEGORIES

a. Detailed descriptions of the various soils and subsoils are contained in the RE Supplementary Pocket Book No 5D, Soil Mechanics, 1952, (WO Code No 8679) and in other recognized books on the subject. For the practical purposes of recovery, however, they may be conveniently considered in four categories:

(1) firm ground unaffected by moisture, eg: rocky surfaces, stones on a firm foundation, shale, etc;

(2) soils that are firm when dry but which become comparatively unstable in wet weather, eg: clay and its various combinations with chalk, sand, etc;

(3) soils that are unstable under any conditions, eg: soft cultivated soils, bogs, marshland, etc;

(4) soils encountered on beaches, foreshores and estuaries that may be affected by tidal action, eg: sand, shingle, silt, etc.

b. It must be remembered, however, that in any one area there may be more than one type of sub-soil. Clay pans may be found in a sandy area or boggy patches in an otherwise firm hillside or the soil may be a mixture, eg: chalk and clay.

309. ROCKY AND STONY SURFACES

These are easily recognized and require little description. They may be very rough and uneven while sharp stones and edges may cause punctures. When the surface is wet, wheel-spin or slip may result. Normally, except for difficulties arising from steep slopes or hard going, they cause few recovery problems other than difficulty in driving in stakes or pickets for holdfasts.

310. CLAY SOILS

a. Clay may be found in pure form such as white china clay or blue stately clay. More often it is in combination with sand, chalk, etc and is then known as loam, marl, adobe, loess, etc and varies in colour from yellow to red or brown. The various combinations have their own specific qualities that must be learned from experience. For example, loess, which occurs in large areas in Europe, is very friable in dry weather. Clay type soil generally has the following characteristics:

(1) when dry and unbroken it provides a good weight-bearing surface;

(2) when a surface is wet, slip and wheel-spin are likely;

(3) when very wet, so that it begins to lose consistency, it exercises a strong holding or suction effect on vehicles and vehicle wheels embedded in it;

(4) it will usually support a holdfast well, although difficulty may be experienced in removing it owing to holding or suction;

(5) areas of clay type soil that have been broken up by transport and the surface of which has subsequently dried may form a treacherous crust through which vehicles will break without warning.

311. SAND

a. Sandy soil is easily recognized but its suitability for vehicles is subject to considerable change according to its condition. In fact it has two distinct and opposite characteristics:

(1) When slightly wet it holds together in a fairly solid mass and withstands pressure. Its consistency is greatly increased by the presence of course grass or vegetation such as exists in some dune areas. Its ability to withstand shear is always very limited.

(2) When dry and powdery, sand has very little cohesive strength and provides no hold for wheels or tracks unless there is a large area of contact. To compete with this difficulty, balloon tires are fitted to vehicles that have to work in sandy areas while tire pressures are lowered when travelling over soft sand. Sand-channels are provided as normal unditching equipment for wheeled vehicles.

312. BOG, PEAT AND MARSHLAND

a. Bogs, as distinct from marshes and swamps, may be encountered in both high and low ground. They usually consist of a depressed clay foundation containing water on which rests peat or other comparatively firm soil. They vary in depth from a few inches to many feet and in some of them a vehicle can be fully submerged in a few minutes.

Great care must be taken that men avoid unnecessary risks when working in such areas. Recovery vehicles and anchors must be kept on firm ground clear of the boggy area and full use made of long ropes for winching.

b. Marshy or swampy ground is easily distinguished in temperate climates by the presence of green vegetation and grasses. The effect on vehicles is more easily estimated than in boggy country although the presence of underlying water makes recovery operations difficult and often causes vehicles to sink deeply. It is important to find or construct a firm flat surface from which a recovery vehicle can work. Buried holdfasts may be necessary.

313. BEACHES AND FORESHORES

Beaches may be of shingle, sand or in a river estuary, silt. Generally speaking the difficulty of recovery in such areas is affected by the slope of the beach and the rise and fall of the tide as much as by the nature of the ground. Speed is usually of primary importance owing to the risk of damage by waves and of further subsidence with each successive tide. Owing to their lack of cohesion, shingle and pebbles may cause serious difficulty to movement of vehicles especially if the slope is considerable. Pebbles tend to roll under tires and to jam in tracks and sprockets.

314. SILT

Silt is the finely grained muddy sand or sedimentary deposit brought down by a river to its estuary. Recovery from silt is very difficult, especially when water is likely to rise and fall through it causing complete loss of cohesion. Approach to casualties is often difficult and they are likely to be bellied. Holdfast spikes are useless and it may be necessary to construct buried earth anchors.

315. SNOW AND ICE

The first characteristic of snow and ice surfaces is that wheeled vehicles require overall or non-skid chains in order to obtain a grip. The use of these chains is described in Chapter 12, Section 2. Heavy soft snow is a serious obstacle to movement or recovery especially

owing to its tendency to pack up in front of a vehicle that is being driven or towed. Tightly packed snow of this type will usually have to be dug away before a vehicle can be moved and it may be necessary to improvise some form of snow plough if there is none available.

CHAPTER 4

THE APPLICATION OF ELEMENTARY MECHANICS TO THE RECOVERY TASK

SECTION 1 - GENERAL

401. The extrication and recovery of an equipment or vehicle casualty is achieved by applying a force or forces to move it in the desired direction. In order to apply these forces in the most effective and economical manner, recovery personnel must acquire some knowledge of the elementary principles of applied mechanics. This will entail the study of force and motion.

402. To make the best use of this knowledge recovery personnel must be able to assess quickly and accurately the resistances to movement which must be overcome and which may be due to one cause or a combination of causes, eg: weight of casualty, nature of ground, rolling resistance, damage or gradients. They must also be aware of the capabilities of the equipment available and be able to select, after assessing the task, the most suitable equipment and the best method of using it.

403. This theoretical knowledge, augmented by practical experience in recovery, will enable crews to plan a recovery operation so as to use the minimum of equipment, ensure the maximum safety to men and material and carry out the task quickly and efficiently.

SECTION 2 - WORK, POWER AND ENERGY

404. FORCE

Force may be defined as that which tends to produce or alter the motion of a body. The unit of force generally used in engineering is the pound weight and the force expressed is the gravitational pull on a mass of one pound in the latitude of London, England. For convenience force is sometimes expressed in tons or other units. The connection between the force of gravity and forces applied in a recovery operation is a basis of comparison for the purposes of measurement. Thus, when it is said that a winch exerts a pull of ten tons, it means that the pull is equal in magnitude to the gravitational force on a mass of ten tons.

405. WORK

a. When a force acting on a body causes it to move against a resistance the force is said to do work. The amount of work done is the product of the force and the distance moved provided the force is in the direction of the motion and is constant in magnitude.

b. The unit of work generally used by engineers is the work done when a force of one pound acts through a distance of one foot, this unit being called a foot-pound. If a force of one ton acts through a distance of one foot it is called a foot-ton and the work done when a force of one pound acts through a distance of one inch is called an inch-pound.

Example:

A recovery vehicle towing a casualty at an even speed exerts a steady horizontal pull of two tons through a distance of 1,000 feet. Work done in foot-pounds = 2 x 2,000 x 1,000 (ie, force x distance)

= 4,000,000 foot-pounds.

c. Work done in rotation. Assume a force of seven pounds is applied tangentially at the circumference of a pulley of two-foot radius (see Figure 3), then in one revolution of the pulley the work done will be:

$$\begin{aligned}\text{Force X distance} &= \text{force x circumference}\\ &= 7 \times 2\pi \times 2\\ &= 88 \text{ foot-pounds}\end{aligned}$$

Note: If the force remains constant, the work varies directly as the radius.

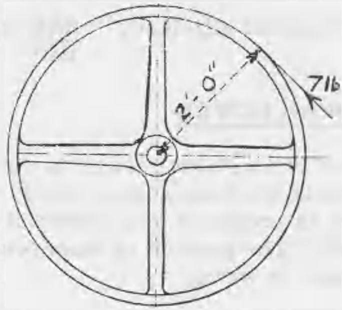


Figure 3 - Force applied to a pulley

406. POWER

a. Power is the rate of doing work or the work done per unit of time. A large amount of work can be done by a small engine in a long time but only a powerful engine can do a large amount of work in a short time. Power is measured by the amount of work done per second (or per minute) and the unit used in engineering is 550 foot-pounds per second (or 33,000 foot-pounds per minute). In the example given in paragraph 405 b. the recovery tractor did 4,000,000 foot-pounds of work. If the distance was covered in two minutes, then:

$$\text{Horsepower} = \frac{4,000,000}{33,000 \times 2} = 60.6$$

b. The indicated horsepower (IHP) of an internal combustion or of a compression-ignition engine is the actual power developed in the cylinder by the combustion of the fuel. All the indicated horsepower is not available for useful work because some is lost in the engine in friction and wasted heat.

c. Indicated horsepower minus horsepower lost in the engine is called the brake horsepower (BHP) of the engine, after the apparatus used to measure it.

d. The ratio $\frac{\text{brake horsepower}}{\text{indicated horsepower}}$ is called the mechanical efficiency and is always less than unity. Mechanical efficiency is often expressed as a percentage.

$$\text{Mechanical efficiency} = \frac{BHP}{IHP} \times 100$$

407. ELECTRICAL POWER

a. The unit of electrical power is the watt which is the rate of working when a steady current of one ampere is produced by a potential difference of one volt. The product of amperes and volts gives the power in watts.

b. The power of 746 watts is equivalent to one horsepower. Thus a 200-volt motor consuming electricity at a rate of 100 amperes gives a theoretical power output of 20,000 watts (20 kilowatts).

$$\text{Horsepower} = \frac{20,000}{746} = 26.8$$

408. ENERGY

a. A body is said to possess energy when it is capable of doing work. Two forms important in recovery work are potential energy and kinetic energy.

b. Potential Energy. This is energy stored in a static body which may be due to its position in the case of a suspended weight or to materials being under strain as in stretched elastic or a compressed spring.

c. Kinetic Energy. This is energy stored in a moving body such as a rotating flywheel or a moving vehicle. Potential energy is released by the weight falling, the elastic contracting or the spring expanding, whereas kinetic energy is released if resistance is offered to the motion of the flywheel or vehicle.

d. If the release of energy is not controlled, by lowering the weight gently, for instance, or by stopping the vehicle slowly, damage may occur through shock effect.

SECTION 3 - WORK AND MACHINES

409. PRINCIPLE OF WORK APPLIED TO A MACHINE

a. A machine can be defined as a mechanism by which force can be applied to do work against a resistance or load.

b. In all machines the work done by the force in a unit of time is equal to the sum of the useful work done on the load and the work done in overcoming the resistance in the machine. This is known as the principle of work.

c. If the work done in overcoming resistance in the machine itself is disregarded, then for any given interval of time the work done by the force will be equal to the work done on the load.

Work done by force = work done on load
From the definition of work, force x motion of force = load x motion of load, or

$$\frac{\text{motion of force}}{\text{motion of load}} = \frac{\text{load}}{\text{force}}$$

410. MECHANICAL ADVANTAGE OF A MACHINE

The ratio $\frac{\text{load}}{\text{force}}$ is known as the mechancial advantage of a machine.

411. VELOCITY RATIO OF A MACHINE

The ratio $\frac{\text{motion of force}}{\text{motion of load}}$ is known as the velocity ratio of a machine.

412. EFFICIENCY OF A MACHINE

a. The efficiency of a machine is given by the ratio

$$\frac{\text{work done on load}}{\text{work done by force}}$$

This may be written as $\frac{\text{load x motion of load}}{\text{force x motion of force}}$ or

$$\frac{\text{mechanical advantage}}{\text{velocity ratio}}$$

b. In the case of the perfect machine with no frictional losses this ratio would be unity and the mechanical advantage would equal the velocity ratio.

c. Because frictional losses are unavoidable in machines, the efficiency is always less than unity and is normally expressed as a percentage.

SECTION 4 - PRIMARY MACHINES

413. GENERAL

a. The kind of machine used in recovery is a contrivance for overcoming resistance at some point by means of a force applied at another point. For example, the force applied manually or by an engine may be converted by lever or by winch into a force sufficient to right or move a vehicle casualty.

b. It is important to note that no increase in power can be obtained by the use of a machine since the total work obtained from a machine cannot exceed the total amount put into it. However, a machine does make it possible to obtain a mechanical advantage.

c. The three primary machines, all of which are used in recovery work in one form or another, are:

(1) the lever, examples being the handspike, crowbar, wheel and the brake pedal of a vehicle;

(2) the cord, which includes any machine in which force is transmitted through a flexible rope or chain passing over one or more pulleys or sprockets, examples are rope tackles and hoist chains;

(3) the inclined plane, which is a machine having an inclined surface introduced to the direction of motion, examples of an inclined plane are screw threads, wedges and ground slopes.

414. MOMENTS

a. A knowledge of the principles of moments is required to understand the action of the lever.

b. The effect of a force on a body depends not only on the magnitude and direction of the force but also on the position or point of its application. The effect of a push to open or close a door will be greater the further it is from the hinge.

c. The turning effects or moment of a force about a point is found by multiplying the magnitude of the force by the perpendicular distance from that point to the line of action of the force. When a number of forces acting on a body are in equilibrium, the opposing moments of forces acting about any axis must be equal.

d. Moments are spoken of in terms of pound-feet, pound-inches, etc so as to distinguish them from foot-pounds and inch-pounds of work.

e. In Figure 4, if AB is the line of action of a force of eight pounds, the moment of the force about a point P which is three feet perpendicularly from AB is:

$$8 \times 3 = 24 \text{ pound-feet.}$$

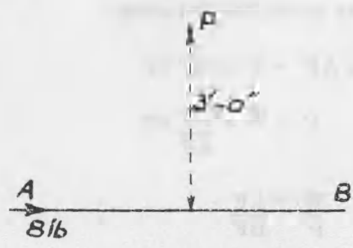


Figure 4 - Moment of a force

415. LEVERS

a. A lever is a rigid bar, such as a handspike or crowbar, capable of pivoting about a fulcrum. It is a primary machine which can be used in three different ways.

b. In the first case the lever has its fulcrum F between the load and the force, as illustrated in Figure 5 (a). If the force is applied downwards, as shown by the arrow P, the end of the lever will raise the load W. The lever is frequently used thus in recovery when moving a heavy object or component.

c. In the second case the lever is loaded between the fulcrum and the force as shown in Figure 5 (b). In this arrangement the load will move in the same direction as the force.

d. An example of this application in recovery is the use of a crowbar with the claw resting on the ground and the load taken between the claw and the handle.

e. In the third case the force is applied between the load and the fulcrum as shown in Figure 5 (c). In this arrangement the load again moves in the same direction as the force. This method is of little use in recovery.

416. MECHANICAL ADVANTAGE OF LEVERS

a. Referring to Figure 5 (a), (b) and (c), if P represents the force and W the load, then by taking moments about the fulcrum:

$$P \times AF = W \times BF \text{ or}$$

$$P = W \times \frac{BF}{AF} \text{ or}$$

$$\frac{W}{P} = \frac{AF}{BF}$$

b. The ratio load to force, ie the mechanical advantage, is thus given by the ratio of distance of force from the fulcrum to that of load from fulcrum. In the arrangements at Figures 5 (a) and (b) it is obvious that AF can readily be made longer than BF and the force required to balance will be less than the load.

c. For example, in the case of a handspike, if the distance AF from force to fulcrum was six feet and the distance BF from fulcrum to load was one foot, then a force of 150 pounds would raise a load of $150 \times \frac{6}{1} = 900$ pounds.

417. VELOCITY RATIO OF LEVERS

Referring again to Figure 5 (a), when the lever is moving about the fulcrum the ratio of the velocity of motion of the force P to that of the load W is equal to the ratio of the distances AF to BF, P moving faster than W.

$$\text{Velocity ratio} = \frac{\text{motion of force}}{\text{motion of load}} = \frac{AF}{BF}$$

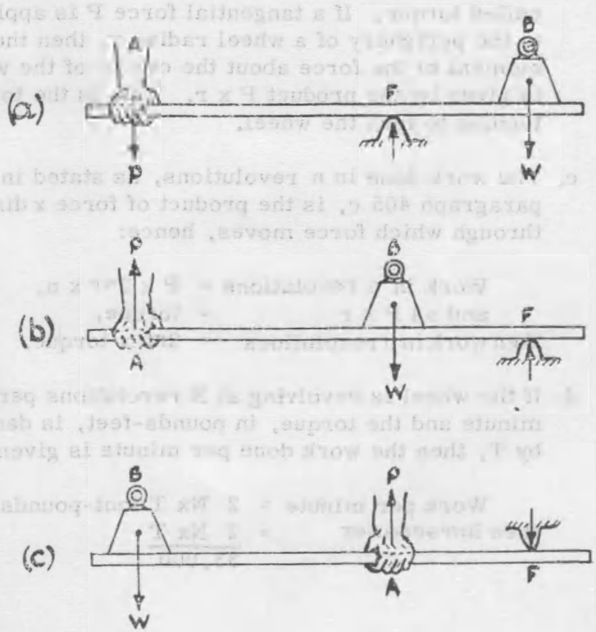


Figure 5 - Levers

418. WHEEL AND AXLE

a. If a lever, pivoted at its centre, is made to rotate, it simulates a wheel, as shown in Figure 6 and the principles quoted in connection with levers can be applied to the wheel.

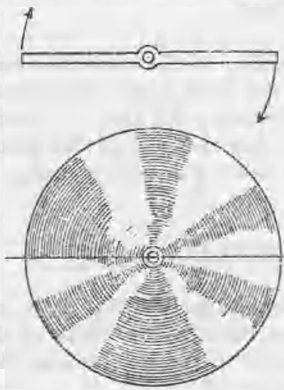


Figure 6 - Lever simulating a wheel

b. The moment of the force which turns a wheel is called torque. If a tangential force P is applied to the periphery of a wheel radius r, then the moment of the force about the centre of the wheel is given by the product $P \times r$. This is the torque tending to turn the wheel.

c. The work done in n revolutions, as stated in paragraph 405 c, is the product of force x distance through which force moves, hence:

$$\begin{aligned} \text{Work in } n \text{ revolutions} &= P \times 2\pi r \times n, \\ \text{and as } P \times r &= \text{torque}, \\ \text{then work in } n \text{ revolutions} &= 2\pi n \times \text{torque}. \end{aligned}$$

d. If the wheel is revolving at N revolutions per minute and the torque, in pounds-feet, is denoted by T, then the work done per minute is given by:

$$\begin{aligned} \text{Work per minute} &= 2\ N \times T \text{ foot-pounds} \\ \text{then horsepower} &= \frac{2\ N \times T}{33{,}000} \end{aligned}$$

For example:

The winch of the Centurion ARV Mk 2 has a drum of 22 inches diameter which turns at 4.34 revolutions per minute when exerting a pull of 30 tons. To find the horsepower exerted:

$$\text{Horsepower} = \frac{2 \times \pi \times 4.34 \times 30 \times 2000 \times 22}{33,000 \times 2 \times 12}$$

$$= 45.5$$

419. CORD

a. The cord, as a primary machine is a means of transmission of motion and power and also a means by which the direction of a pull may be changed. The type of primary machine of this nature most often used in recovery is a tackle where the cord is passed round blocks fitted with one or more sheaves, as shown in Figure 7. There is a pair of sheaves in each block and there are four parts of rope between the blocks as well as that end of rope, called the fall, which is to be pulled by hand or winch.

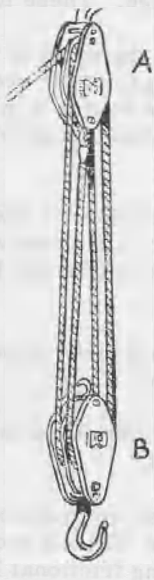


Figure 7 - Four-part tackle

b. As with other simple machines, the efficiency of a tackle layout is given by the ratio $\frac{\text{work done on load}}{\text{work done by force}}$. As shown in Section 3 of this chapter this ratio may be expressed as:

$$\frac{\text{Load}}{\text{Force}} \times \frac{\text{Distance moved by load}}{\text{Distance moved by force}} \quad \text{or}$$

$$\frac{\text{Mechanical advantage}}{\text{Velocity ratio}}$$

420. VELOCITY RATIO

The velocity ratio of a tackle layout is the distance moved by a force in moving a load through a unit of distance and depends upon the form of the layout.

421. MECHANICAL ADVANTAGE

a. In any tackle, if there were no losses due to friction, the mechanical advantage would be equal to the velocity ratio. This is the theoretical gain or advantage of the tackle. In practice the losses due to friction may seriously diminish this theoretical advantage. These losses may be due to:

(1) friction of the parts of the rope against each other or against the shell of the block - this loss can be kept to a minimum by keeping the parts parallel and preventing the blocks from twisting;

(2) friction between the sheaves and the pin - the loss due to this cause will be kept to a minimum if the blocks are kept clean and well lubricated;

(3) the force required to bend the rope round the sheave;

(4) friction of the ropes and blocks dragging over the ground.

b. To make a close estimate of the efficiency of a tackle layout is difficult because of the number of factors affecting frictional losses.

c. The coefficient of friction used in calculating the mechanical advantage in a tackle varies from about one-fifth to one-tenth depending upon the state of the tackle but with tackle in good condition and with minimum ground drag it may be taken as one-tenth.

422. EFFICIENCY OF TACKLE LAYOUTS

a. For practical purposes the figures given in the following table may be used:

Number of sheaves	Velocity ratio	Efficiency %	Mechanical advantage
1	2:1	90	1.8
2	3:1	83.3	2.5
3	4:1	76.9	3.1
4	5:1	71.4	3.6
5	6:1	66.6	4.0

b. The above are the efficiencies to be expected under favourable conditions where the coefficient of friction is taken as one-tenth. If the layout is on muddy ground with the ropes dirty and sheaves clogged the effect of friction will be increased. The fall in efficiency as the number of sheaves increases explains why it is undersirable to employ simple tackles with more than six sheaves.

423. INCLINED PLANE

a. The principles of the inclined plane apply to screw threads, wedges, chocks, jacks and gradients.

b. Referring to Figure 8, the force P in raising the weight W through five feet must move a distance of ten feet. Velocity ratio is $\frac{10}{5} = 2$. The theoretical mechanical advantage is 2 to 1.

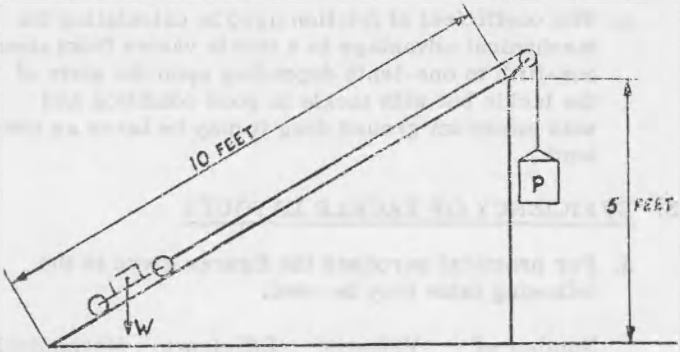


Figure 8 - Inclined plane

SECTION 5 - STRENGTH OF MATERIALS

424. GENERAL

a. Loads in recovery work are produced as a result of resistance to motion of an equipment casualty. These loads are usually created by either rolling resistance or grade resistance or both (see Section 6 of this chapter). Whatever their magnitude they combine to form the total load which has to be tackled by recovery vehicles and their associated equipment.

b. An elementary knowledge of the effects of forces acting on materials in different ways will help recovery personnel to avoid overloading equipment with the possibility of damage to it and to themselves.

c. Figure 9 shows a recovery vehicle exerting a simple 2:1 pull with the use of a winch and snatch block, the winch rope being anchored to the ground. Some effects of overloading the tackles are illustrated.

425. STRESS AND STRAIN

a. The words stress and strain are often used incorrectly. In the science of mechanics they both have very precise and entirely different meanings.

(1) Stress is the combination of internal forces in material under load. This is indicated in terms of force per unit area, eg: pounds per square inch or per square foot.

(2) Strain is the change in form or dimensions in material under load, eg: the elongation of wire in a stretching rope. Strain is calculated from the ratio:

$$\frac{\text{Change in dimensions}}{\text{Original dimensions}} \quad \text{eg:} \quad \frac{\text{Change in length}}{\text{Original length}}$$

426. THE ELASTIC LIMIT

a. Elasticity is that property of matter which causes it to return to its original shape and dimensions after the removal of a load which has caused strain such as stretching or twisting.

b. A bar of steel will stretch if it is stressed by applying a gradually increasing pull to it. At first the extension of the bar will be uniform for each equal increment of load but a point will be reached when the extension is no longer proportional to the increase in load. This point is called the elastic limit and after it has been passed, the material will no longer return to its original shape and dimensions when the load is removed. Because of this important fact, great care must be taken not to overload a material to such an extent that there is a permanent change in its shape and dimensions.

c. Fracture may occur very quickly if the load on a piece of material is further increased after the elastic limit has been reached. This is called the breaking load of the material and the breaking stress is calculated by dividing the breaking load by the original cross sectional area of the piece at the place of fracture.

427. FACTOR OF SAFETY

a. Under working conditions materials may be subject to unforeseen and perhaps unforeseeable stresses. A factor of safety which will allow for

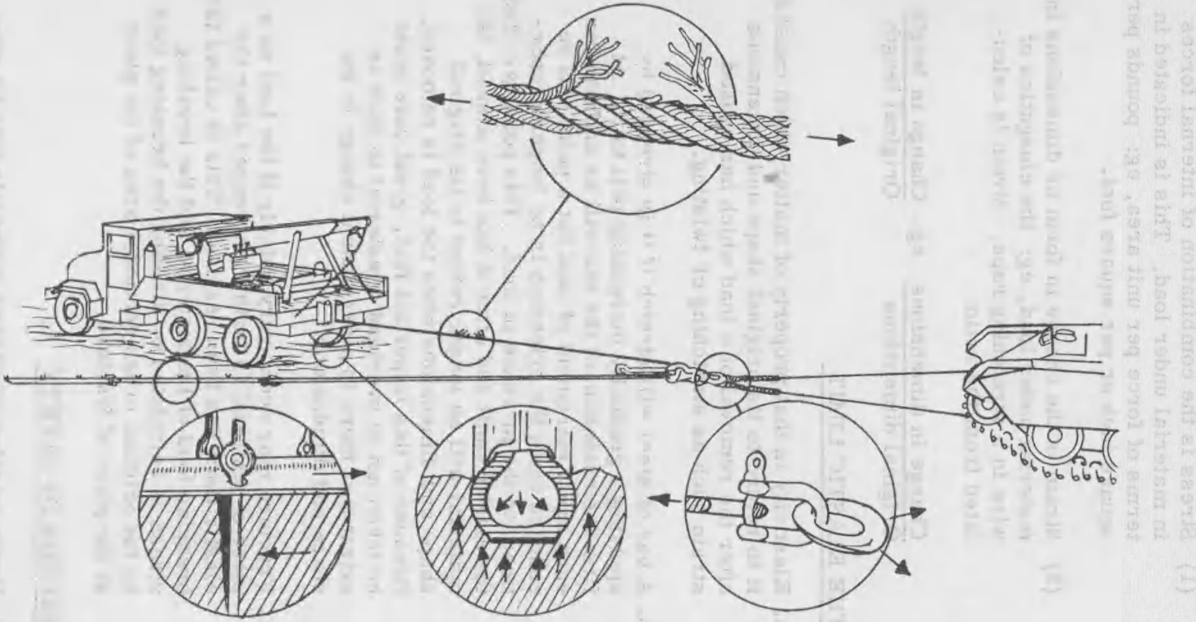


Figure 9 - Recovery vehicle exerting a 2:1 pull

this is therefore used in designing. If the safe working load, often marked "SWL" on the equipment, is five tons while theoretically the equipment would break at 25 tons, a factor of safety of five has been used:

$$\text{Factor of safety} = \frac{\text{Breaking load}}{\text{Safe working load}}$$

b. Whatever the safety factor, however, only the safe working load of equipment must be considered when calculating its suitability for use.

428. KINDS OF STRESS

a. There are three types of stress as follows:

(1) Tension. When a piece of material is pulled, as in the case of a winch rope, it is under tension. The effect is to cause the material to stretch. If the load is increased beyond the breaking load, the fibres of the material will part, usually at the weakest point in the rope. If the rope returns to its original size when the load is removed then the load has been within its elastic limit although it may have been beyond the safe working load. The cross-section of a flexible material, when loaded beyond the elastic limit, reduces very rapidly just prior to the break owing to the material actually flowing. This reduction is called necking. There is one feature which gives warning that the elastic limit of a piece of material has been reached particularly if it is forged, cast, galvanized or painted. This feature is a scaling of the surface and is due to the deformation of the fibres of the materials causing the overlaying skin or paint to break or chip off. Wire rope will stretch appreciably and uniformly. Long before the individual wires approach their elastic limit, the strands tend to straighten out and in so doing compress the core (which is resilient). If the load is excessive individual wires will begin to snap and the load must be removed immediately in order to avoid breakage of the rope.

(2) Compression. When a piece of metal such as a bar is subjected to a thrust at both ends, as illustrated in Figure 10 (a), it is said to be under compression. The behaviour of a material when under compression is governed by the relation of the length to its cross-section. A long strut may bend when over-loaded whereas a short piece of the same cross-section, under the same load, will break up in the case of cast iron, flatten in the case of lead or shear in the case of steel. A lifting jack is a good example of a simple machine which, when loaded, is subject to compression.

(3) Shear. When a material is so stressed that one portion tends to slide over an adjoining portion it is said to be in shear, as in Figure 10 (b). An example of material subject to shear stress is the threaded pin in the shackle connecting snatch block and tow rope in Figure 9.

429. TORSION

When a bar is fixed at one end and is subject to a twisting force at the other end, as shown in Figure 10 (c), the bar is under torsion. At any cross-section of the bar the material is in shear as one portion is tending to slide over the adjacent portion. If the material is stressed within its elastic limit it will return to its original form.

430. BENDING

When a beam, supported at both ends or fixed at one end (cantilever), is subjected to a load it will tend to bend. The stresses set up in any cross-section of the beam are seen in Figure 10 (d) to be tension, compression and shear. Provided the beam is not stressed beyond the elastic limit of the material it will return to its original shape.

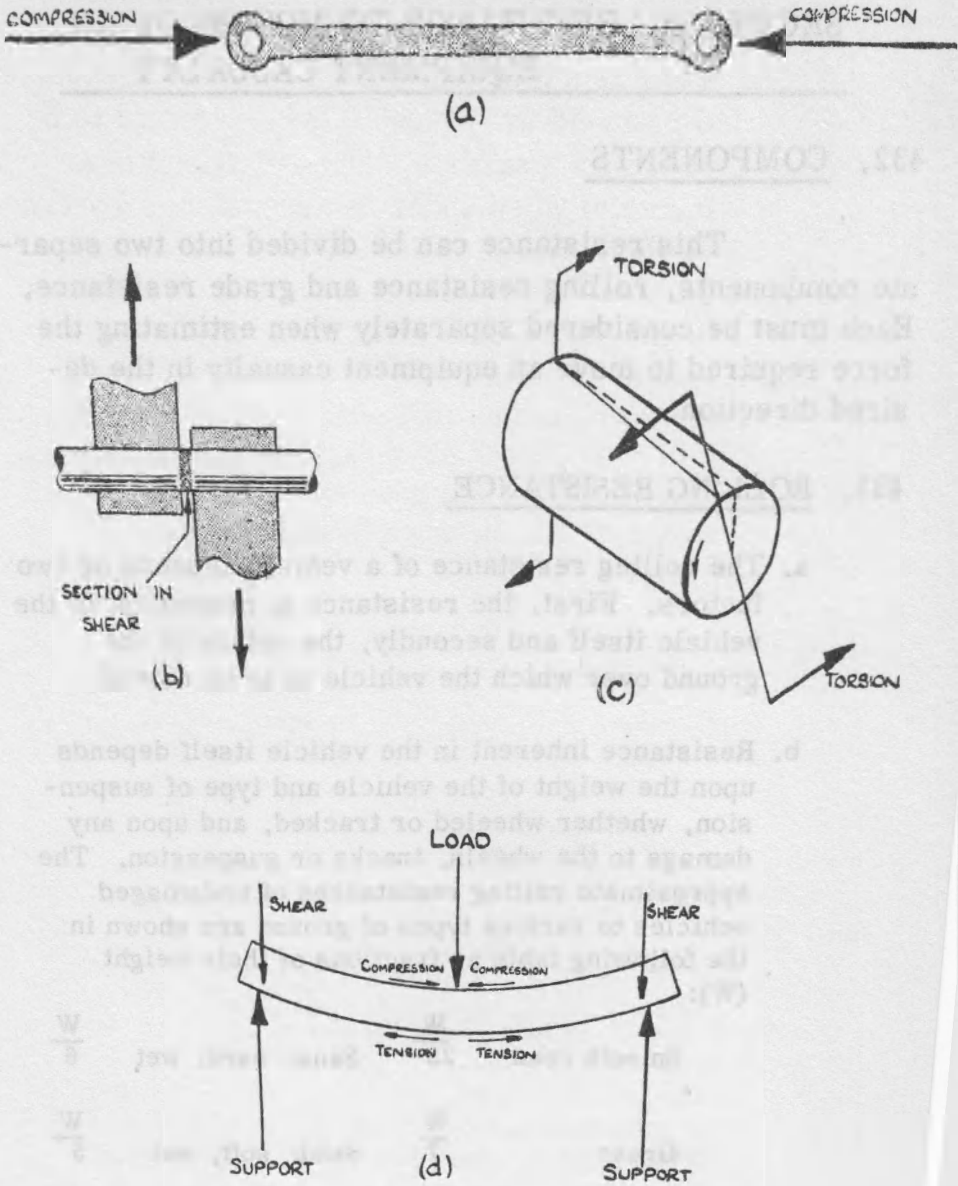


Figure 10 - Tension, compression and shear

431. FATIGUE

a. When a part of a machine is subject to a live load, ie a varying load as opposed to a dead or constant load, the material may fail at a fraction of the constant load required to cause failure. The cause of this failure is fatigue. Components which are subject to a live load require a high factor of safety in their design.

b. Sudden failure is usually the first indication of fatigue although some materials will show minute cracks as an early sign of fatigue.

SECTION 6 - RESISTANCE TO MOTION OF AN EQUIPMENT CASUALTY

432. COMPONENTS

This resistance can be divided into two separate components, rolling resistance and grade resistance. Each must be considered separately when estimating the force required to move an equipment casualty in the desired direction.

433. ROLLING RESISTANCE

a. The rolling resistance of a vehicle depends on two factors. First, the resistance to movement of the vehicle itself and secondly, the nature of the ground over which the vehicle is to be moved.

b. Resistance inherent in the vehicle itself depends upon the weight of the vehicle and type of suspension, whether wheeled or tracked, and upon any damage to the wheels, tracks or suspension. The approximate rolling resistances of undamaged vehicles to various types of ground are shown in the following table as fractions of their weight (W):

Smooth road	$\frac{W}{25}$	Sand: hard, wet	$\frac{W}{6}$
Grass	$\frac{W}{7}$	Sand: soft, wet	$\frac{W}{5}$
Gravel	$\frac{W}{5}$	Sand: loose, dry	$\frac{W}{4}$
Shingle beach	$\frac{W}{3}$	Black mud	$\frac{W}{2}$
Soft blue clay	$\frac{W}{2}$		

c. If the vehicle is damaged the resistance to motion may be greatly increased and this increase must be estimated from experience and added to the resistance to movement of the vehicle itself and the resistance due to the type of ground.

434. GRADE RESISTANCE

a. The inclined plane is discussed in paragraph 423. The angle of the slope governs the size of the force required to haul a load up the slope.

b. Up to an angle of 45 degrees the grade resistance of an equipment casualty may be taken as 1/60th part of its weight for each degree rise. Hence, for a 15 degree slope it would be one-quarter of the weight of the casualty.

c. A slope greater than 45 degrees is seldom encountered in recovery work. If it is, the full weight of the casualty must be taken.

435. TOTAL RESISTANCE

a. When assessing the total resistance to motion of an equipment casualty, therefore, an estimate must be made of the rolling resistance and the grade resistance due to any slope up which it may be necessary to haul the casualty.

b. The sum of these must be increased by a factor of safety to allow for any inaccuracies in estimating and for any unforeseen resistance which may be encountered during the extrication of the casualty.

c. The final sum is therefore as follows:

Let W = Rolling resistance of casualty.

Let Y = Grade resistance.

Then estimated total resistance $Z = W + Y$

Add 25% for contigencies

$$\text{Total resistance } R = Z + \frac{Z}{4}$$

$$= \frac{5Z}{4}$$

d. For example, if a tank weighing 52 tons is lying in a shell crater with one track jammed, the estimate of the total resistance of motion could be done as follows:

(1) The first step is to estimate the inherent rolling resistance as if the tank were on level ground but with the tracks in the same depth of mud as that in the crater. This estimate might reasonably be:

$$\frac{\text{Weight of vehicle}}{3} = \frac{52}{3} = 17.3 \text{ tons}$$

(2) Next, the rolling resistance due to damage must be estimated. After emergency repairs to the track, sufficient damage will probably still remain to provide a rolling resistance of five tons for example.

(3) The grade resistance is then calculated. If the slope of the crater sides is estimated at roughly 30 degrees, it will be equal to:

$$\frac{\text{Weight of vehicle} \times 30}{60} = \frac{52 \times 30}{60} = 26 \text{ tons}$$

(4) The total resistance can now be calculated:

Rolling resistance of casualty	= 22.3 tons
Grade resistance	= 26.0 tons
Sub total	48.3 tons
Add 25% for contingencies	= 12.1 tons
Total resistance to motion	= 60.4 tons (say 61 tons)

e. The Centurion ARV Mk 1 has a winch pull of 25 tons maximum and with the spade anchor dug in this ARV is capable of withstanding up to 75 tons reaction. Recovery of the casualty having a total resistance to motion of 61 tons could be carried out with this ARV using a three to one simple tackle layout to produce a pull of approximately 75 tons.

CHAPTER 5

LIFTING AND HAULING GEAR

SECTION 1 - GENERAL

501. In addition to recovery vehicles and the equipment fitted to them, there is a large variety of other equipment and materials used in recovery. For example, fibre or steel ropes or both are required for nearly every recovery job. A thorough general knowledge of their characteristics is necessary if efficient and safe use is to be made of them. Without this knowledge, cordage may be subjected to a load that it is not designated to stand or slings and shackles may be wrongly rigged so that they bend or break under stress. In either case, serious damage may result to men or material.

502. The aim of this chapter is to describe the most important features of the lifting and hauling gear in general use for recovery. The methods of servicing, inspecting and storing this equipment are described in Chapter 14.

SECTION 2 - CORDAGE

503. DEFINITION

Cordage is a general term used to describe fibre ropes and yarns as distinct from wire ropes.

504. TYPES AND CHARACTERISTICS

a. The ropes used for lifting and hauling are generally made from manilla, hemp or sisal but cotton, coir and nylon are employed for special purposes. Coir makes a light elastic rope of no great strength that will float, cotton rope is easy to handle and nylon is used where strength and lightness are more important than cost.

b. Cordage stretches considerably under load. The stretch in a new rope, when subjected to its working stress, is about one-twentieth of its length.

505. CONSTRUCTION

a. Ropes are made by twisting a number of fibres of the raw material to form a yarn, then a number of yarns to form a rope. The way in which the strands are twisted together is called the lay of the rope, the angle of lay being the angle between the direction of each strand and the direction of the centre line in the rope.

b. Ropes used in recovery work are rot-proofed.

c. Spun yarn is made from one to 18 yarns, various types of fibre being used. It is used chiefly for seizing and whipping.

506. MEASUREMENT AND IDENTIFICATION

a. The size of the rope is invariably denoted by its diameter in inches while its length is measured in feet.

b. Identification and description of cordage is contained in the Canadian Army Catalogue of Ordnance Stores, Stock Class 4020.

507. STRENGTH

a. The following are breaking strengths of two grades of rope used in recovery work:

Rope, sisal, natural	1/2-in diameter	2120 lbs
Rope, manilla, natural	1/2-in diameter	2560 lbs
Rope, manilla, natural	1-in diameter	9000 lbs
Rope, manilla, natural	2-in diameter	31000 lbs
Rope, manilla, natural	2 5/8-in diameter	52000 lbs

b. Wear and exposure to weather have a cumulative effect in decreasing the strength of a rope and a liberal safety factor must be allowed for ropes in poor condition.

c. The strength of cordage, when taken round a sharp bend, slung over a hook or knotted, is decreased about one-third owing to the fibres being unevenly stressed. In calculating the rope working load under these conditions, the estimated safe working load must be reduced by from 30 to 50 percent.

SECTION 3 - STEEL WIRE ROPES

508. GENERAL

Steel wire rope is stronger and less liable to stretch than cordage but it is not so flexible and it is therefore more difficult to handle.

509. CONSTRUCTION

a. Wire rope is made up of a number of strands surrounding a core of tough fibre such as hemp. The strands are composed of separate wires, the number of wires depending on the flexibility required and in some wire ropes the strands themselves have a fibre core for increased flexibility.

b. The number of wires in a strand varies but usually six strands are used to make a rope. There is a recognized method of indicating the construction of a rope, ie 6/7 indicates a six-stranded rope with seven wires in each strand, 6/19 indicates a six-stranded rope with 19 wires in each strand.

c. Normally the wires composing the strands are twisted together in an anti-clockwise direction. This is known as right hand ordinary lay. Twists in the opposite direction give left hand ordinary lay.

d. A type of wire rope frequently employed in recovery is preformed or trulay. In this type the strands are given the exact helical form they will follow in the completed rope. These ropes do not corkscrew or spiral when left loose, hence kinks rarely occur. They do not require shipping before cutting and they are easier to splice. For identification, preformed wire rope may have one of the strands painted light blue.

510. MEASUREMENT AND IDENTIFICATION

Unlike cordage, the method of measuring steel wire rope is not uniform. In recovery gear, steel wire rope is frequently measured by its diameter but owing to lack of uniformity of practice the words "diameter" or "circumference" as applicable should be added when

specifying size. Length is usually given in feet but the fathom is sometimes used. A fathom is six feet. Identification and description of steel wire rope is contained in the Canadian Army Catalogue of Ordnance Stores, Stock Class 4010.

511. STRENGTH OF STEEL WIRE ROPES

a. The strength of steel wire ropes depends upon two main factors:

(1) the cross section of the rope,

(2) the material from which the rope is made.

b. Data giving breaking strengths can therefore be related to the diameter of the rope and the type of material from which it is made.

c. The following are breaking strengths of various grades of wire rope used in recovery work:

Wire rope, IP Steel, galvanized finish, fibre centre, 6 by 19, 7/8-in diameter	29 tons
Wire rope, IP Steel, galvanized finish, fibre centre, 6 by 37, 3/8-in diameter	3.9 tons
Wire rope, IP Steel, plain finish, fibre centre, 6 by 19 No 2, 7/8-in diameter	3.2 tons
Wire rope, IP Steel, plain finish, wire rope centre, 6 by 25, 1/2-in diameter	11.5 tons

Breaking loads of wire ropes of UK construction are detailed in Table 1.

d. In civilian practice, where safety is a primary consideration, factors of safety from approximately five for horizontal pulls and up to 30 for elevators are used. For military purposes, the needs for compact and light equipment compel the designer to use a much lower factor of safety.

e. For example, the factor of safety used in calculating the size of a winch rope to be used in an ARV may be as low as two, or even less, but there is an additional safety factor provided by the incorporation of an automatic overload cutoff in the winch itself.

f. Safe working loads for wire ropes used in recovery operations should be calculated with a safety factor of approximately two. When assessing the safe working load of steel wire ropes, it must be remembered that the breaking loads given in paragraph 511 c. and Table 1 apply only to ropes which are in good condition. Allowance must be made if the rope is suspect.

g. For rough estimates, when using steel wire ropes in good condition, the safe working load in tons can be calculated approximately from the formula 1 1/3 C2 where C is the circumference of the rope in inches.

SECTION 4 - BLOCKS AND TACKLES

512. GENERAL

a. Single pulley or single sheave blocks are used to change the direction of a pull and also, with one or more pulleys or sheaves made up into tackles, for gaining mechanical advantage.

b. Tackles are composed of one or more blocks, each containing one or more pulleys or sheaves, reeved with the required number of ropes or parts.

513. BLOCKS

a. Cordage blocks used in recovery consist of two metal sides or cheeks which form the shell and which carry one or more grooved pulley wheels or sheaves. A swivel hook is fitted to the top and a ring or becket is fitted to the bottom of the block.

b. The dimension of a cordage block always refers to the diameter of the rope to be used with it, eg: Block Tackle, 1/2-in fibre rope, double. Safe working loads for cordage blocks are detailed in Table 3.

c. Use of cordage blocks is limited in recovery work and is mainly confined to the application of steady tackles. Figure 11 shows single and multiple sheaved cordage blocks reeved to form

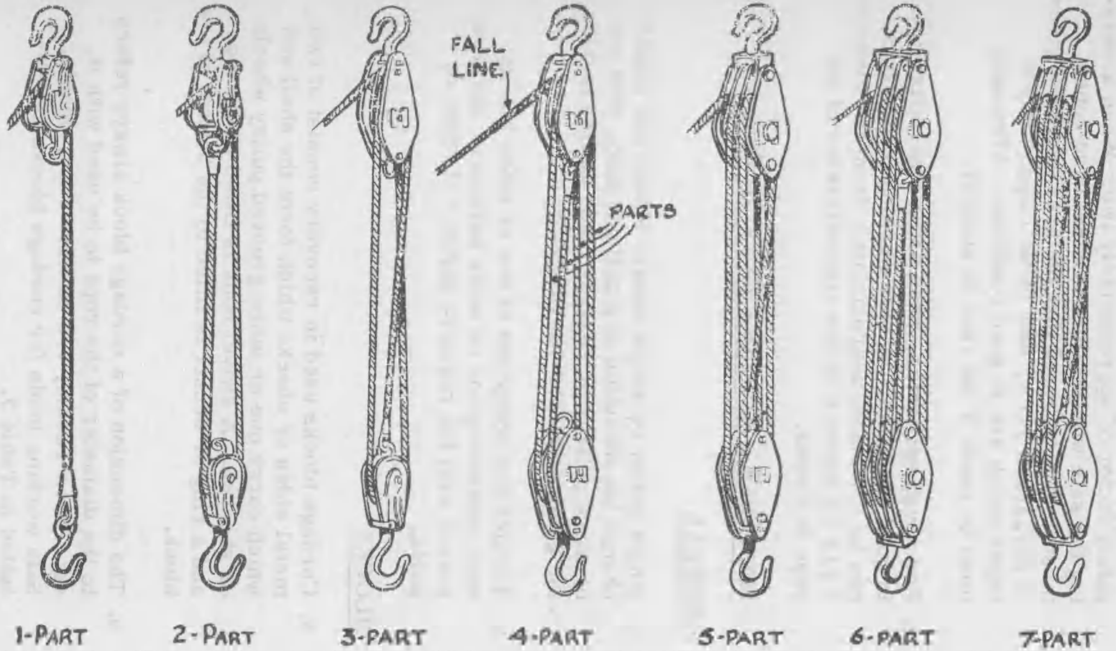


Figure 11 - Tackles

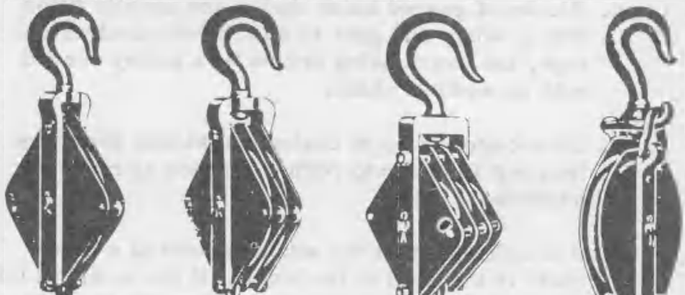
tackles for single part and 2-, 3-, 4-, 5-, 6-, and 7- part working and arranged for lifting a load.

d. Snatch blocks are single pulley or sheave blocks with an opening in one side of the shell so that a rope can be reeved without passing the end through the block. This opening is closed by a hinged strap. Multiple sheave cordage blocks normally have no snatch device.

514. WIRE ROPE BLOCKS

a. Steel wire rope blocks are of metal construction designed for heavy usage and a specified working load. A block is identified by the diameter of the wire rope to be used with it and whether it is single, double or triple sheaved or a snatch type.

b. Figure 12 shows various types of wire rope blocks used for recovery. Safe working loads are detailed in Table 4.



SINGLE DOUBLE TRIPLE SNATCH

Figure 12 - Wire Rope Blocks

c. Servicing of wire rope blocks is important. The oil reservoir in the sheave must be kept filled. The sheave and rope guard require frequent inspection for damage and the hinged flap should open and close freely.

515. HOIST CHAINS

a. Hoist chains are designed to give a high mechanical advantage and in recovery their main use is for short lifts when fitted to booms of recovery vehicles. Figure 13 illustrates a common type of hoist chain. The mechanical advantage is gained either by the use of a differential pulley block or a geared pulley block.

b. Differential hoist chains consist of two pulley wheels of different diameter keyed onto the same shaft. An endless chain is passed round both pulleys which are processed so that the links cannot slip over them and two bights are left hanging down. One bight carries a small free pulley with a hook to take the weight of the load and the other hangs loosely. Pulling on the latter will raise or lower the load. The blocks of these hoists will not overrun with the weight of the load when the effort is removed.

c. Blocks of geared hoist chains are usually fitted with a worm and gear to gain mechanical advantage, the worm being driven by a pulley reeved with an endless chain.

d. Lubrication of hoist chains and blocks should be frequent in order to reduce friction as much as possible.

e. It is accepted that the weakest point of a hoist chain is the hook of the block. If the tackle is laid out to give a direct pull the load on the block is equal to the pull required to move the casualty. If a block is used to change the direction of pull then the load on this block, depending on the angle, can be up to double the pull. This latter point must not be overlooked when estimating the size of the hoist block required for heavy operation. (See paragraph 608 d)

f. Description and identification of hoist chains will be found in the Canadian Army Catalogue of Ordnance Stores, Stock Class 3950.

Figure 13 - Hoist Chain

SECTION 5 - PORTABLE WINCHES

516. GENERAL

The hand-operated portable winch has a wide variety of uses in recovery work especially where power driven winches are not immediately available. Portable winches can be used for righting overturned vehicles and can, with the aid of ancillary equipment, deal with simple recovery of light tracked vehicles. These winches must be anchored and so are provided with an anchor loop.

517. PRINCIPLE OF OPERATION

The hand-operated portable winch used in recovery operates on the ratchet principle. It is operated by a lever, one end of which fits over the squared end of a shaft carrying a pawl mechanism. The pawl engages the teeth of a large ratchet wheel driving the rope drum which is mounted on a spindle carried by a winch frame. As the lever can be long and the drum diameter less than the ratchet wheel diameter, a mechanical advantage is obtained.

518. TYPES OF WINCHES

Portable winches used in recovery are of the two-speed type with a low speed for use when hauling and a high speed for taking up the slack or reeling in the unloaded rope.

519. STRENGTH OF WINCHES

The capacity of a winch is given in its specification, eg: Winch, drum, hand operated, single head, 2 ton capacity. One man can normally operate the winch and two men will be able to load the winch to capacity. The use of three men will produce a loading in excess of the capacity. Therefore, if two men cannot move the load, it is desirable to lay out a tackle to reduce the loading on the winch.

SECTION 6 - SLINGS

520. DEFINITION

Slings are short lengths of wire rope, cordage, or chain made up to attach loads to a lifting or hauling tackle.

521. CORDAGE SLINGS

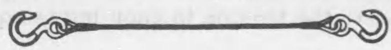
Cordage slings consist of a length of cordage with the two ends spliced together. They are used for light work and for articles that would be damaged by a wire rope or chain bearing on them. The sling is passed round the article to be lifted and the bight formed by one end is passed through the bight formed by the other end and then over the hook of the lifting or hauling tackle.

522. WIRE ROPE SLINGS

a. Wire rope slings are assembled in various forms and lengths including:

(1) endless slings, consisting of a length of wire rope with the two ends spliced together which are often protected by having spun yarn or other whipping material wrapped round them.

(2) Single legged wire rope assemblies which are lengths of wire rope with a thimble and hook or thimble, hook and link at each end as depicted in Figure 14.



(a)

(b)

Figure 14 - Single leg assemblies

b. Two (or more) legged slings can be made up by means of two single legged assemblies attached to a single ring or tackle.

523. CHAIN SLINGS

Chain slings are made up in similar manner to rope slings. They are more durable than wire rope and cordage slings but are seldom used in recovery work because they are not as easy to handle, being heavier than wire ropes of the same strength and requiring periodic annealing.

524. STRENGTH OF SLINGS

a. The safe working load of cordage and wire rope sling assemblies is generally less than that of the rope from which they are made owing to splicing at the thimble. Allowance is also necessary for the effect of sharp bends in the rope over hooks, etc. The safe working load of a sling is therefore taken as one fifth of the breaking load of the material from which it is made.

b. Two (or more) legged slings undergo a rapid increase in loading as the legs are spread apart.

c. When the legs of a two-legged sling are inclined at an angle with the vertical line through the point of support, the tension in each leg is equal to:

$\frac{W}{2} \times \frac{Y}{Z}$ where W = load
Y = length of each leg
Z = vertical distance between the support and the ends of the legs

d. In a two-legged sling lifting a weight W tons, when the legs hang vertically, the load on each leg is $\frac{W}{2}$ tons but if the angle between the legs is 120 degrees, then the load on each leg is W tons, since Y = 2Z for this angle.

SECTION 7 - HOOKS, LINKS AND SHACKLES

525. USE

Hooks, links and shackles are generally used for attaching a hoisting or hauling rope to the load. They

are forged from wrought iron or steel. High tensile steel is often used in the strongest type.

526. HOOKS

Hooks are provided in a variety of forms and some types are illustrated in Figure 15. It is essential that the hook enters the attachment correctly. It must have freedom of movement to avoid becoming strained.

527. LINKS

Links are used to make up slings, to provide a convenient articulated connection between two points in a tackle layout and to couple up to existing towing shackles or towing eyes. Some types of links are illustrated in Figure 16.

528. SHACKLES

a. There are a number of shackles used in recovery called anchor, chain, bow and plate. The chain is illustrated in Figure 17. Shackles can be a source of danger and trouble unless they are properly used and maintained. Overloading causes distortion so that the pins become immovable, the threads on the pins become burred, etc.

b. Plate shackles such as those shown in Plate 1 are commonly used in recovery work. The essential feature of this type of shackle is that if an overload sufficient to bend the bolts should occur, the shackle may readily be released since both nuts can still be removed. Plate shackles are not intended to take side loads.

c. Large shackles of the triangular plate type designed to take loads up to 90 tons, in recovery of Centurion tanks, are illustrated in Plate 2.

(a) Hook, chain, S type

(b) Hook, grab, clevis type

(c) Hook, grab, direct eye

Figure 15 - Hooks

(a) Link, chain, connecting

(b) Link, chain, swing

Figure 16 - Links

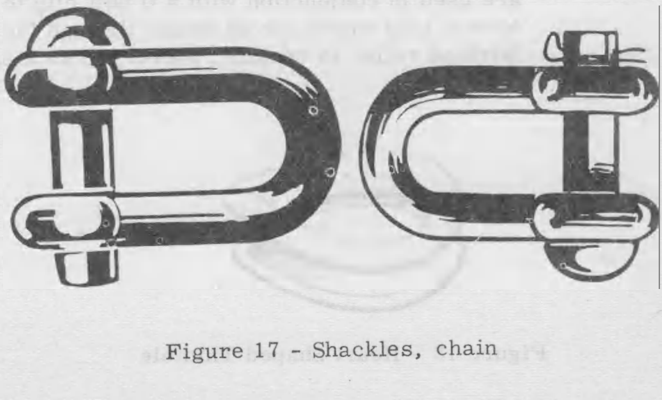


Figure 17 - Shackles, chain

SECTION 8 - ROPE FITTINGS AND TURNBUCKLES

529. THIMBLES

a. Thimbles are spliced into the ends of cordage and steel wire ropes to form a strengthened permanent loop and so provide a means of attachment for lifting and hauling. They are grooved on the outside to take the size of rope for which they are specified and are usually made of galvanized mild steel.

b. Both cordage and steel wire rope thimbles are dimensioned according to the diameter of the rope for which they have been made. Thimbles for steel wire rope may be used for cordage but those for cordage are not suitable for steel wire rope.

c. In the case of both cordage and steel wire rope thimbles, crushing of the underside of the crown of the thimble by excessive loading distorts the material and is liable to cause failure.

d. The types of thimble most often used in recovery are:

(1) Heart-shaped thimbles as shown in Figure 18. These thimbles are for general use.

(2) Reeving thimbles as shown in Figure 19. These are elongated so as to allow a heart-shaped or a reeving thimble of the same nominal size to pass through the eye.

(3) Solid thimbles as shown in Figure 20. These are used in conjunction with a U bolt clip to form a loop which can be drawn through the fairlead roller in certain recovery vehicles.

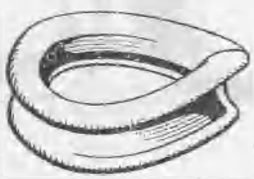


Figure 18 - Heart Shaped Thimble

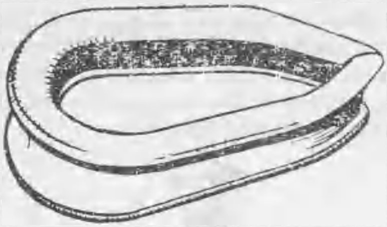


Figure 19 - Reeving Thimble

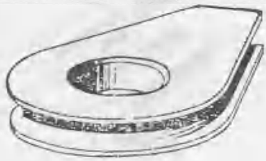


Figure 20 - Solid Thimble

530. GRIPS AND CLAMPS

a. There are two commonly used quick methods of clamping or joining wire ropes:

(1) The U bolt clip is shown in Figure 21. These clips are used with solid thimbles, also for securing together two pieces of rope. The method of using U bolt clips with a thimble is given in Chapter 14, Section 3.

Figure 21 - U-Bolt Clip

(2) Bolted clamps are shown in Figure 22. These are used for securing together two parts of a steel wire rope. Clamps are dimensioned according to the circumference of the rope for which they are suitable.

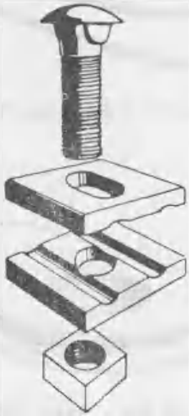


Figure 22 - Bolted Clamp

531. TURNBUCKLE

The various forms of turnbuckles generally used in recovery work usually incorporate a left and right hand screw or in some cases a screw thread at one end only and a swivel fitting at the other. Their use is in securing vehicle casualties on to the decks of trailers or transporters and for straining or tightening purposes during recovery operations. Figure 23 illustrates three forms of turnbuckle.

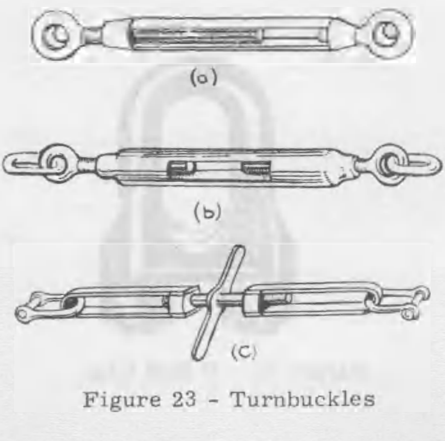


Figure 23 - Turnbuckles

CHAPTER 6

ANCHORING AND POSITIONING EQUIPMENT

SECTION 1 - GENERAL

601. A recovery vehicle frequently requires anchoring when using its winch to extricate a casualty. Even with wheels or tracks locked, the resistance offered by the vehicle itself is often insufficient to hold it against the pull of its winch. Tackles also require anchoring when used to give an indirect pull and sometimes to gain a mechanical advantage.

602. Positioning equipment is used when initial movement of the equipment casualty is necessary before it can be extricated. For example it may be essential to raise the casualty and place skidding underneath before it can be pulled out.

SECTION 2 - ANCHORING EQUIPMENT

603. CHOCKS

a. Some wheel chocks used for recovery are of the wooden type shown in Figure 24. The chocks are placed under the front wheels and are usually attached by chains to the vehicle chassis.

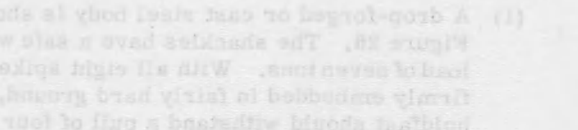


Figure 24 - Wooden chock

b. The metal wheel chock illustrated in Figure 25 is also in wedge form but made of steel. One is placed under each front wheel and anchored to the chassis by wire rope. On soft ground the chock is laid under the wheel to form a wedge similar in action to the wooden chock. On hard ground the pan is turned over to form a platform on which the wheel rests.

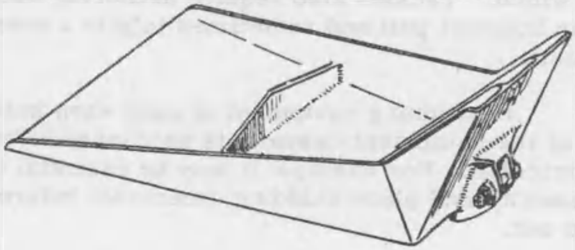


Figure 25 - Metal chock

604. HOLDFASTS

a. Holdfast earth anchors are fixed to the ground by the means of spikes. Three of the various types used in recovery are shown in Figures 26, 27 and 28.

(1) A drop-forged or cast steel body is shown in Figure 26. The shackles have a safe working load of seven tons. With all eight spikes firmly embedded in fairly hard ground, the holdfast should withstand a pull of four tons. For a heavy load, a number of anchors are laid end to end and shackled in line to give the required reaction. Where improved quality shackles of high tensile steel are fitted, holdfasts may be laid four in line since the end shackle can withstand a load of 16 tons.

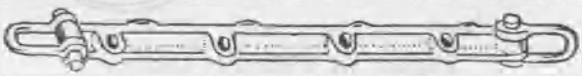


Figure 26 - Cast holdfast

(2) A welded or fabricated type body and shackles of similar specification to the above is illustrated in Figure 27.

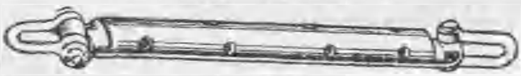


Figure 27 - Welded holdfast

(3) A pressed steel body with a shackle at one end and attaching lugs at the other is shown in Figure 28. It is as strong as but lighter than the cast type shown in Figure 26. The lugs or jaws at the right hand end (as shown) pass through the jaws of the left hand end of the next holdfast in line and are coupled through the bolt holes. The design is sufficiently strong to permit four holdfasts to be placed in line without overstressing any part but any shackle then inserted must not be less than 16 tons SWL.

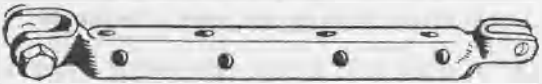


Figure 28 - Pressed steel holdfast

(4) A light-weight pattern used by airborne units is similar to the fabricated type in Figure 27 but has only six holdfast spikes.

b. An eye is formed in the head of the holdfast spikes through which another spike can be inserted to give a twist before withdrawal is attempted and these spikes are octagonal to facilitate removal.

605. NATURAL AND ARTIFICIAL FEATURES AS ANCHORAGES

a. Advantage may be taken of any suitable natural or artificial anchorage that may be available such as large trees, rocks, posts and other vehicles.

b. Masonry pillars and columns must be avoided since these have little strength to withstand a horizontal pull.

606. THE BURIED EARTH ANCHOR

a. Where the ground is suitable, a buried earth anchor can be used if nothing better is available but its construction requires a large effort from the crew.

b. The maximum resistance offered depends on the strength of the buried timber and on the resistance of the earth. The best position for the buried timber is where it provides a pull that is as nearly horizontal as possible.

c. Gunplanks are normally used and when laid at a depth of eight feet, in firm ground, they will withstand a pull of 12 tons per square foot of their frontal area provided the angle of the rope to the horizontal is less than 30 degrees. Under these conditions a resistance of 60 tons can be obtained from a six foot gunplank, allowing for the loss of one square foot for the rope attachment.

607. ANCHORING WHEELED RECOVERY VEHICLES

a. Where wheel chocks are not sufficient to anchor a wheeled recovery vehicle, there are two simple makeshifts that can be employed:

(1) Dig a trench behind the rear wheels and reverse the vehicle so that the rear wheels drop into the trench. Caution is necessary to avoid bogging down the recovery vehicle itself.

(2) Use a gunplank positioned between the rear driving wheels.

608. REACTION AT ANCHORAGES

a. In order to be effective an anchorage must be capable of providing an opposing reaction equal to or greater than the pull applied to it. However, the anchor will fail if the pull exceeds the potential reaction. This failure may be due to the spikes

providing an insufficient hold in the ground or the holdfast or its shackles failing.

b. Figure 29 shows a means of obtaining a balanced pull in two parts of a rope using a single-sheave snatch-block attached to an anchorage. The sheave is reeved with a single rope which is carrying a pull of R tons. Clearly there is no load on the anchorage when the rope is straight, ie while the angle between the two ropes remains at 180 degrees, but immediately the angle between the ropes is reduced below this figure a load is exerted on the anchorage as shown in Figure 29 (b). Here the angle is reduced to 120 degrees and the load on the anchorage has risen to R tons.

c. The load on the anchorage for various rope angles shown in Figure 29 is given below:

(1) At 180^{o} - (a) there is no load.

(2) At 120^{o} - (b) load is R tons.

(3) At 90^{o} - (c) load is 1.4 R tons.

(4) At 60^{o} - (d) load is 1.7 R tons.

(5) At 30^{o} - (e) load is 1.9 R tons.

(6) At 0^{o} - (ropes parallel) - load is 2 R tons.

d. For practical purposes the following formulae may be used:

Angle of rope				Load on anchorage
180	...	...	...	Zero
120	...	...	...	R
90	...	...	...	1 1/2 R
60	...	...	...	1 3/4 R
30	...	...	...	2 R

where R is the pull on the rope.

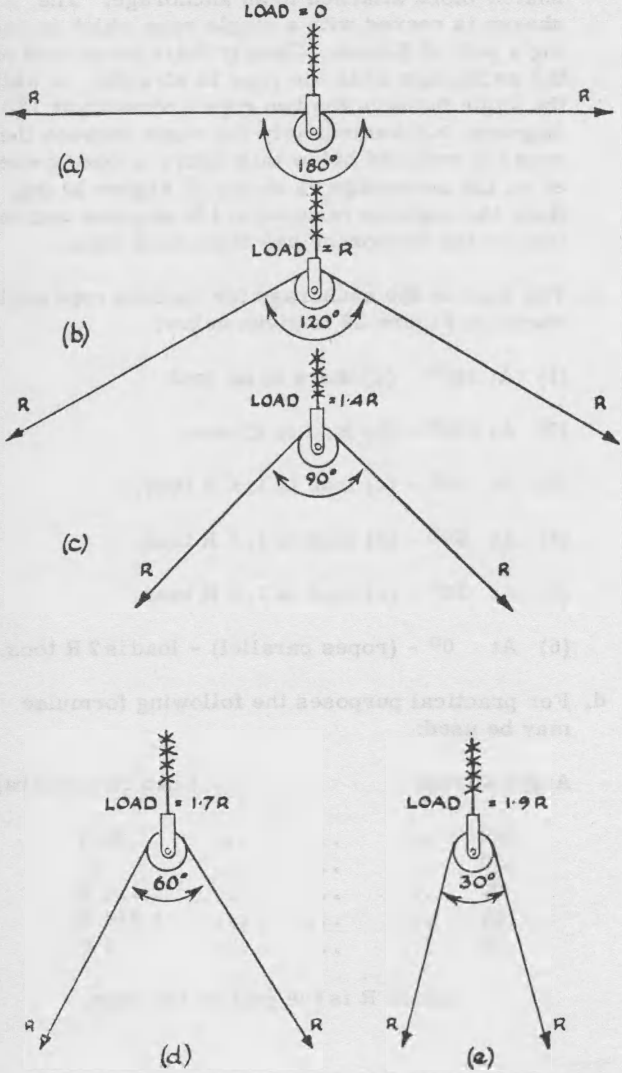


Figure 29 - Reaction at an Anchorage

609. SPADE ANCHORS

Chocks are not entirely satisfactory for heavy recovery vehicles and better results have been obtained by using a large spade hinged to the rear of the vehicle. The spade can be lowered to dig into the ground and brace the vehicle against the rearward pull when winching. A spade anchor of this type fitted to the Centurion ARV Mk 2 is illustrated in Plate 3.

610. GROUND SPADES

A heavy spade cannot easily be used with a light recovery vehicle but the principle can be applied by fitting smaller ground spades which are hinged to the chassis at the rear of the vehicle. Plate 4 illustrates this type of anchor.

SECTION 3 - POSITIONING EQUIPMENT

611. LEVERS

a. Some levers used in recovery are:

(1) The seven-foot lever shown in Figure 30 is used for raising damaged components that are too heavy for lifting by hand alone but which do not warrant the use of tackle or jacks.

(2) A seven-foot handspike is similar to the seven-foot lever but has a plain end or foot without steel sheathing.

(3) The crow-bar illustrated in Figure 31 is a general purpose steel lever of considerable strength.

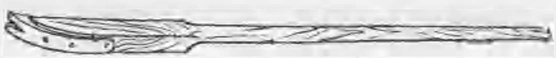


Figure 30 - Lever

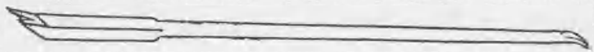


Figure 31 - Crow-bar

612. NOSING PROPS

For moving an equipment on hard ground the nosing prop is effective. The type depicted in Figure 32 is used with the Centurion ARV Mk 2. On hard ground it can be used to rotate a tank in a few minutes, much more quickly than by towing. Nosing props must be used with care especially on vehicles which have large rounded surfaces on which the end of the prop may slip when the load is applied. Where possible skids or gun planks will be used to take the thrust of the prop on the vehicle casualty. All personnel must stand clear when a nosing prop is being used.

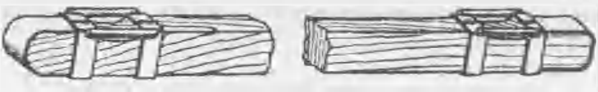


Figure 32 - Nosing prop

613. SKIDS, GUN-PLANKS AND ROLLERS

a. Appliances provided for making a firm base and to facilitate movement of loads include the following:

(1) Skids of hard wood in standard sizes of 3 feet x 6 inches x 3 inches or 3 feet x 9 inches x 6 inches. They are used for propping and in jacking operations. See Figure 33.

(2) Gun-planks, 6 feet x 12 inches x 3 inches made of oak, for assisting the passage of an equipment casualty or recovery vehicle over broken terrain as well as for propping jacking operations, etc. See Figure 34.

(3) Ground rollers, 3 feet x 6 inches, used in conjunction with skids or gun planks to ensure free movement of loads or ease of travel of recovery tackle. See Figure 35.

Figure 33 - Skid

Figure 34 - Gun-plank

Figure 35 - Rollers

CHAPTER 7

TACKLE LAYOUTS

SECTION 1 - GENERAL

701. Tackle layouts provide a most useful method of obtaining a mechanical advantage in recovery work. A number of tackle combinations can be made up by the use of blocks (both single and multi-sheave), ropes and earth anchors. Each combination has its advantage or disadvantage and recovery personnel must have a very thorough knowledge of these. The selection of a tackle layout depends not only on the nature of the task but also on the ability of the recovery equipment and the ground to withstand the loads imposed.

SECTION 2 - BASIC PRINCIPLES OF TACKLE COMBINATIONS

702. GENERAL

a. An understanding of tackles will be approached by first considering the uses of the single-sheaved block. If a single-sheaved block is anchored as in Figure 36 (a) then, neglecting friction, the force P required to move the load W is equal to W. The velocity ratio is equal to unity and there is no mechanical advantage. What has been achieved is a change in direction of the applied force.

b. When the tackle is arranged as in Figure 36 (b) however, with the winch rope taken round the sheave and its end anchored while the block is fastened to the load, a velocity ratio of two is obtained since two feet of rope must be winched onto the drum in order to move the load one foot. The load on each part of the tackle will be one-half W and this will be the pull required from the winch. This arrangement gives a theoretical mechanical advantage of two to one and the introduction of a second single-sheaved block, as in Figure 36 (c), gives three to one and reduces the load on each part of the tackle to one-third W.

c. To avoid confusion, the nomenclature used in describing the various types of tackle layout likely to be used in recovery is defined as follows:

(1) Tackles are described as two-, three-, six-part, etc, as shown in Figure 11, the number of parts being determined by the mechanical advantage required. The tackles shown in Figures 36 (a) and (b) are single-part tackles and that in Figure 36 (c) is a two-part tackle.

(2) Simple tackles are made up by reeving a rope through one or more blocks containing one or more sheaves.

(3) Compound tackles are the combination of two or more simple tackles, (see Figure 37 (a)) where the theoretical mechanical advantage is four to one and Figure 37 (b) where it is eight to one.

(4) Direct tackles are so arranged that the direction of the pull provided by the winch is unaltered.

(5) Indirect tackles are so arranged that the direction of the pull by the winch is turned through an angle. For example, a tackle might have the description "three-part simple direct."

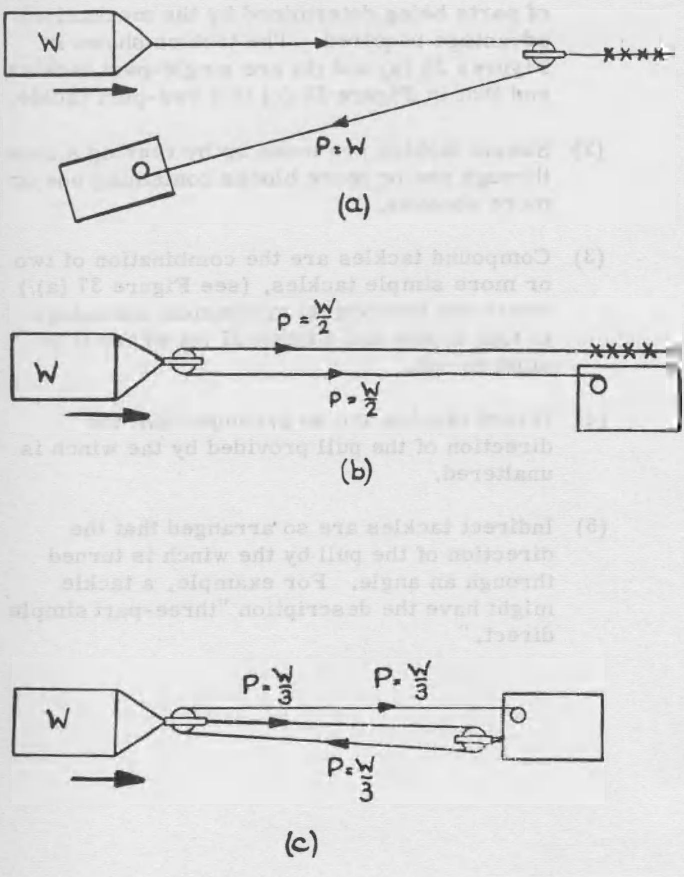


Figure 36 - Simple tackles

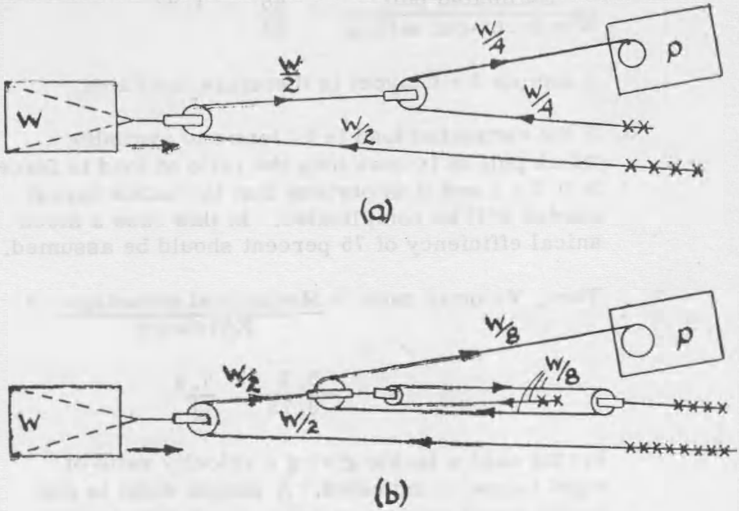


Figure 37 - Compound tackles

703. SELECTING THE TACKLE LAYOUT

a. When considering the recovery problem, the maximum pull of the winch is known from its specification, the direction of pull must be decided and the resistance to motion of the casualty must be estimated. The problem then resolves itself into whether a tackle is necessary and if so what kind and how should it be arranged.

b. The ratio of load to force, or resistance to motion compared with the maximum pull of the winch, will give some idea as to the tackle layout needed. If the resistance is of the order of two or three times the maximum winch pull, a simple layout will probably suffice and the efficiency of the tackle will be high. When the ratio is of the order of five or six to one however, a compound tackle using a number of blocks will be required.

c. For example, if the estimated resistance pull is 48 tons (including a 25 percent safety factor) and the available winch pull is 25 tons, the ratio of load to force is:

$$\frac{\text{Estimated pull}}{\text{Winch cut-out setting}} = \frac{48}{25} = 1.92$$

A simple 2 : 1 layout is therefore indicated.

d. If the estimated load is 57 tons and available winch pull is 10 tons then the ratio of load to force is 5.7 : 1 and it is obvious that the tackle layout needed will be complicated. In this case a mechanical efficiency of 75 percent should be assumed.

$$\text{Then, Velocity ratio} = \frac{\text{Mechanical advantage}}{\text{Efficiency}} =$$

$$\frac{5.7}{0.75} = \frac{7.6}{1}$$

In this case a tackle giving a velocity ratio of eight to one is indicated. A simple eight to one tackle would not be considered owing to its low efficiency and so a compound tackle must be used.

SECTION 3 - LAYING OUT RECOVERY TACKLE

704. GENERAL

When the appropriate tackle layout has been decided, consideration must be given to the probable loadings so that sufficiently strong components can be used. The arrangement of the tackle on the ground must be planned and any necessary ground anchors selected.

705. LOADS ON COMPONENTS

A consideration of the layout chosen will give the loads expected on each part of the rope. The loads on blocks and shackles etc can be estimated from those on the parts of the rope. If the blocks require anchoring then the loads on ground anchors must be estimated. The safe working loads of the components must be sufficient to withstand the loads imposed.

706. GROUND ANCHORS

The method of computing the reaction at anchorages has been given in Chapter 6, Section 2. From this estimate the type and number of anchors needed can be calculated. When earth anchors are being laid down, the

pin at the end farthest from the load should first be knocked in. The slack in the rope is then taken up to pull the holdfast into line. The tension is then eased slightly and the second pin driven in. The rope is then slackened off and the remaining pins driven home.

707. LAYOUT OF TACKLE

a. Distances should be paced out for positioning the recovery vehicles, snatch blocks and anchors bearing in mind:

(1) the distance the casualty must be moved,

(2) the length of the winch rope,

(3) the velocity ratio of the tackle.

b. The rope making up the tackle should be reeved in one direction only, either clockwise or anti-clockwise, round the sheaves in the blocks. This will avoid undue stress and wear in the rope.

c. Ropes should be prevented from dragging through the earth by placing rollers underneath them. The ropes should not be crossed or friction will occur.

d. Plate shackles and quick release shackles should not be subjected to side pulls. All shackles should be sufficiently free so as to be able to line up the direction of the force applied to them.

708. COMPENSATING PULLS

a. In certain cases it is necessary to apply two separate pulls to an equipment casualty to prevent it from pivoting. For example, if a tank has a damaged track and is lying at an awkward angle in a ditch, the application of a central pull will tend to pivot the tank round the damaged track so that it faces the wrong direction.

b. Two pulls should be applied, one to each side of the tank so that the ratio of the tensions at the two connecting points is equal to the ratio of the resistance to motion of the two tracks. In practice there is no means of arriving at an exact

figure for the latter ratio so that sound judgement and experience must be used to devise a satisfactory proportional layout.

c. A compensated layout is possible with a compound tackle and such a layout which needs only the application of a single winch pull is illustrated in Figure 38. This arrangement uses three single sheave snatch-blocks and two earth anchors. In this way a compensated layout has been arranged in which side X of the casualty receives a pull four times that applied to side Y.

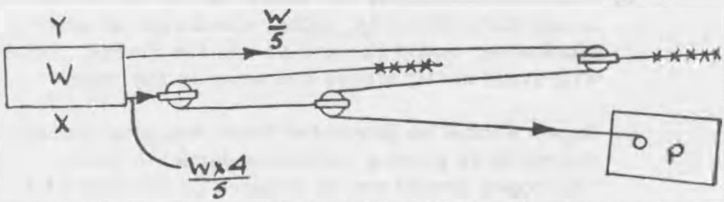


Figure 38 - Tackle giving a compensating pull

CHAPTER 8

RECOVERY VEHICLES

SECTION 1 - BASIC REQUIREMENTS AND CHARACTERISTICS

801. THE TASK

Whatever the casualty, a recovery vehicle must accomplish two things. First, it must approach near enough to the casualty to use its equipment efficiently and quickly. Secondly, it must have sufficient power and tackle to move and so recover the casualty.

802. THE REQUIREMENTS

a. The two main requirements of a recovery vehicle therefore, are mobility and power driven and manually operated recovery equipment.

b. Recovery vehicles which are used in support of armour must also be armoured so as to give protection to the crew.

803. MOBILITY

a. Recovery vehicles must keep up with the units and formations they serve, whether they are moving on roads, across country or through water obstacles.

b. Movement by road requires recovery vehicles to move as fast as other road traffic without damaging the road surface.

c. Cross-country performance of recovery vehicles should equal or exceed that of the equipments in the formation they are supporting.

d. Wading capacity is necessary for recovery operations on beaches and river crossings. Recovery vehicles should be capable of wading in water as deep as that specified for the equipment they are recovering.

804. RECOVERY EQUIPMENT

a. A recovery vehicle may be required to recover an overturned vehicle which cannot be approached closely and which requires righting and then moving to a position from which it can be towed away or placed on a transporter.

b. The recovery vehicle, therefore, must be capable of towing, lifting, hauling and manoeuvring the equipment back onto its wheels or tracks. It must be equipped with a strong towing attachment, a boom for lifting, hand or power operated jacks and a power operated winch for hauling. It will require equipment such as blocks and anchors for laying out tackles and also chocks and crowbars.

805. PROTECTION

A recovery vehicle supporting armour or armoured personnel carriers (APC) will have to operate frequently in close proximity to the enemy and therefore should be well armoured.

806. CHARACTERISTICS

a. It has not been found possible to design one single vehicle to meet all requirements for recovery. Wheeled vehicles may have satisfactory road performance but cannot compete with tracked vehicles in cross-country performance. Tracked vehicles have a good cross-country performance but are relatively slow on roads and tend to damage the surface.

b. Recovery vehicles have led to the development of a series of vehicles, each with a special role. Wheeled vehicles are used for road and easy cross-country going and recovery of wheeled and light tracked vehicles. Tracked armoured vehicles and commercial tracked tractors (bulldozers) are used for difficult terrain and recovery of APCs and heavy tracked vehicles.

c. Wheeled vehicles are capable of travelling long distances by road or even across easy country. Tracked armoured vehicles and commercial tracked tractors are usually carried on transporters when moved by road in order to avoid damage to and wear on tracks.

SECTION 2 - TYPES OF RECOVERY AND BACKLOADING VEHICLES

807. WHEELED RECOVERY VEHICLES

Wheeled recovery vehicles meet the requirements of good road performance and the ability to deal with equipment casualties occuring on roads and easy terrain. They also have good cross-country performance, particularly if all wheels are driven. These vehicles are not armoured for protection.

808. ARMOURED RECOVERY VEHICLES

Armoured recovery vehicles are tracked vehicles designed to deal with tracked vehicle casualties in forward areas. They have a cross-country performance equal to that of the tanks, SP guns and APCs of the formation they support.

809. COMMERCIAL TRACKED TRACTORS

Commercial tracked tractors are tracked vehicles used for recovery work and towing in general and when equipped with attachments, may be used for earthmoving, entrenching vehicles and equipment and operating backloading points. Their manoeuverability is equal to that of tanks, SP guns and APCs, although their speed is very limited in comparison.

810. WHEELED TANK TRANSPORTERS AND TRAILERS

a. Tanks and equipment are transported on semi-trailers with tractors.

b. These trailers may be parked while the tractor does other work. For example, a trailer may be left at the edge of bad ground while the tractor tows the equipment casualty to it.

SECTION 3 - WHEELED RECOVERY VEHICLES

811. Manufacturers handbooks and technical manuals give full details of recovery vehicles now in service. Identification data and illustrations will be found in Canadian Army Catalogue of Ordnance Stores 7610-21-102-1826 and EME Manual Vehicles Z 400, Instruction 3 and Z 420, Instruction 3.

SECTION 4 - ARMOURED RECOVERY VEHICLES (ARV)

812. GENERAL

ARVs are used for recovering armoured vehicle casualties especially in forward areas where protection against enemy fire is required. An ARV is either a tank with the turret removed and the fighting compartment used to house a powerful winch or an APC specially fitted for recovery. Special lifting gear is usually fitted, towing attachments are strengthened and anchoring gear such as the spades shown in Plate 3 are provided. The ARV has a good cross-country performance but is transported for long road journeys. A brief description of ARVs is given below. Further details can be obtained from relevant handbooks, technical manuals and EME Manual Vehicles section.

813. CENTURION ARV MK 2

a. The Centurion ARV Mk 2, illustrated in Plate 5, is a converted Centurion tank. The turret, gun, fighting equipment and forward ammunition bin have been removed and replaced by an armoured cab housing a 30-ton winch. This winch is driven by an electric motor, the power for which is provided by a generator driven by an auxiliary gasoline engine. The space formerly occupied by the ammunition bin is used to house a gasoline tank.

b. A front crane of 10 tons capacity, provided as unit equipment, can be used for lifting or removing major assemblies from tanks.

c. The ARV is fitted with a spade anchor which enables the vehicle to resist a pull of 90 tons. See Plate 3.

814. RECOVERY APC

a. The recovery APC is an APC specially fitted for recovery. This vehicle is in the planning stage only but when produced for use in the Canadian Army it will be a basic carrier, cargo amphibious, full tracked, armoured (illustrated in Plate 9) fitted with a crane and winch. It is proposed to modify the carrier further so that it can:

(1) transport and accommodate a crew of three;

(2) carry special tools, tool kits, and vehicle equipment for recovery only plus personal equipment and miscellaneous stores;

(3) carry POL, water, rations, etc, for short periods during operations.

815. COMMERCIAL TRACKED TRACTORS

a. Commercial tracked tractors (Caterpillar, Allis Chalmers, International Harvester) are used for recovery and towing.

b. The D8 Caterpillar tractor, illustrated in Plate 10, has a towing capacity, in first gear, of up to 20 tons on hard level standing. The towing capacity will decrease as the ground conditions deteriorate.

c. Detailed description and data can be obtained from the relevant handbooks, technical manuals and EME Manual Engineer Equipment section B.

SECTION 5 - TANK TRANSPORTERS AND TRAILERS

816. Manufacturers handbooks and technical manuals give full details of transporters and trailers now in service. Identification data and illustrations will be found in Canadian Army Catalogue of Ordnance Stores 7610-21-102-1826 and EME Manual Vehicles section Z.

CHAPTER 9

TOWING EQUIPMENT

SECTION 1 - GENERAL

901. Towing equipment for vehicle casualties varies from the single steel wire tow-rope, which is part of the equipment of every wheeled vehicle, to the heavy three-part draw-bar designed for tank towing. As a rigid tow is always preferable to a rope tow, recovery vehicles are equipped with tow-bars or draw-bars. Other vehicles, however, carry tow-ropes which are lighter and more easily stowed.

902. Towing gear must be strong enough to withstand the snatch loads which may be imposed, particularly when using a tow-rope. In moving a vehicle from rest, inertia has to be overcome and therefore a greater tractive effort is necessary during the period of acceleration than is required to keep the vehicle in motion. The effort of moving a casualty is transmitted through the towing device and sudden snatches may occur through poor driving.

903. Recovery vehicles are issued to units "as per Equipment Issue Scale (EIS)". The EIS lists the tools and towing equipment which accompany the vehicle. Some of the towing equipment mentioned in the EIS of a recovery vehicle is described in Sections 2 and 3 of this chapter. Recovery crews must be fully conversant with their recovery equipment both as to identification and proper use.

SECTION 2 - TOWING EQUIPMENT FOR WHEELED VEHICLES

904. TOW ROPES

Wire tow-ropes of various lengths and sizes, according to vehicle weight, are supplied for wheeled vehicles. These tow-ropes usually comprise a single length or leg with a thimble spliced in at each end. They may be attached to the towing hooks of the vehicle and the casualty with or without the use of shackles.

905. RIGID TOWING EQUIPMENT

a. Rigid towing equipment used for wheeled recovery includes the following items:

(1) V Tow-Bar. When the vehicle to be towed is lifted in position for towing, which should always be with both lines, the V tow-bar is hooked into the pintle hook of the recovery vehicle. The tow-bar legs are adjustable and should be extended so that the feet touch the part of the load to which they are to be attached by the tow-bar chain. The chain should be wrapped around the bumper, spring horn or tow-hooks and brought back to the toggle catch on the tow-bar. The lever for tightening them should then be closed against the bar. Care should be taken to have sufficient space between the towing and the towed vehicle to allow free movement on turns. Towing with the rear of the towed vehicle in front is handled in the same manner but in this case steering gear clamps should be used to lock the steering mechanism. These clamps are attached to the tie-rod, one on each side of a front spring, so that they will strike the sides of the spring and prevent movement of the tie-rod. See Figure 39.

(2) Towing Bar. This device is illustrated in Figure 40. It can be used for towing wheeled vehicles that do not require a suspended tow. The cross-bar is lashed to the front axle or another suitable part of the vehicle and the tow-bar eye fits over the towing hook of the recovery vehicle. This tow-bar has a pivot between the main bar and the cross-bar to allow swivelling in a horizontal plane.

906. REFERENCES

Detailed operating and maintenance instructions for the medium wrecker M62 are contained in Operation and Maintenance Manuals TM 9-8028 and TM 9-8029-3 and EME Manual instructions, section G.

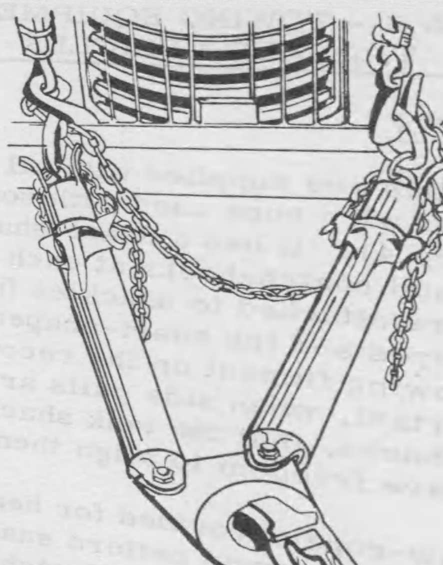


Figure 39 - V Tow-bar

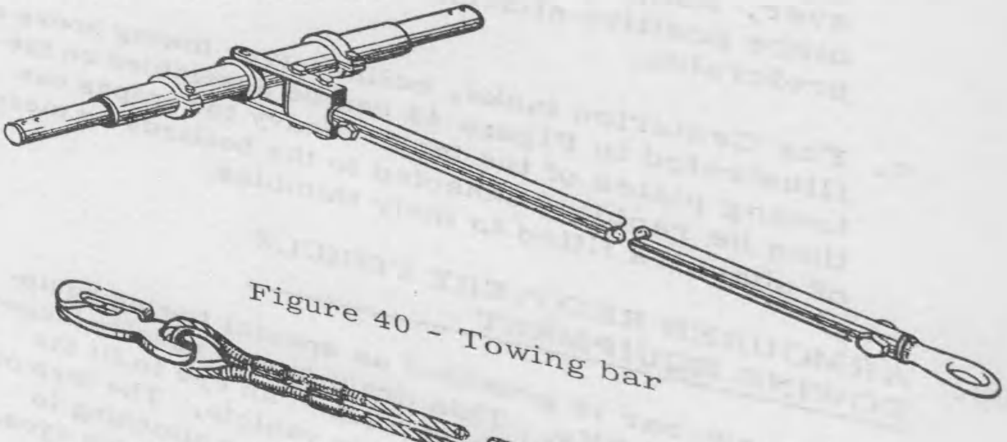


Figure 40 - Towing bar

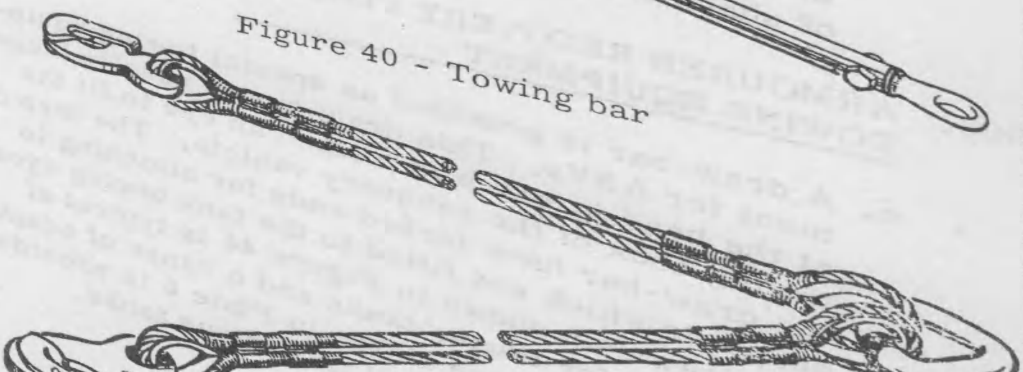


Figure 41 - Tank tow-rope

SECTION 3 - TOWING EQUIPMENT FOR TRACKED VEHICLES

907. TOW-ROPES

a. Tow-ropes are supplied with all tracked vehicles. A typical wire rope used with some tanks is shown in Figure 41. It has a heart-shaped link in the centre and snatch-hooks at each end. The snatch-hooks are attached to shackles fixed to the tank towing eyes and the heart-shaped link is attached to the towing fitment on the recovery vehicle. It is important, when side pulls are exerted on the snatch-hooks, that the tank shackles and the snatch-hooks have freedom to align themselves.

b. Some tow-ropes provided for heavy and medium tanks have improved pattern snatch-hooks as illustrated in Figure 42. Snatch-hooks are, however, liable to open when not under load and a more positive attachment, such as a shackle, is preferable.

c. For Centurion tanks, bollard-type towing hooks as illustrated in Figure 43 can be assembled on the towing plates of the tank. Heavy tow-ropes can then be rapidly connected to the bollards by means of shackles fitted to their thimbles.

908. ARMOURED RECOVERY VEHICLE TOWING EQUIPMENT

a. A draw-bar is provided as special towing equipment for ARVs. This draw-bar is usually hinged at the head in which is formed an eye to fit the towing hook of the recovery vehicle. The legs of the draw-bar have forked ends for attaching to adaptors which are fitted to the tank towing eyes. The draw-bar shown in Figure 44 is typical of those used for towing tanks and a range of adaptors similar to those shown in Plate 6 is provided so that the draw-bar will fit various tanks.

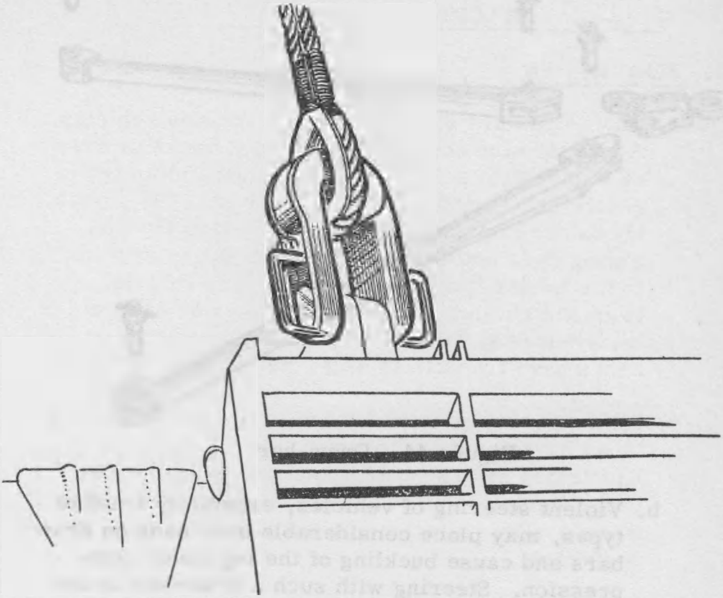


Figure 42 - Snatch-hook

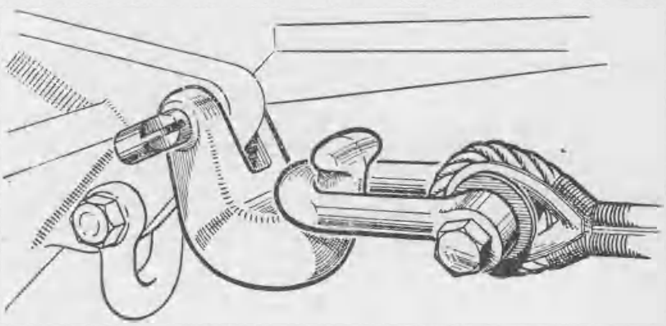


Figure 43 - Bollard towing hook

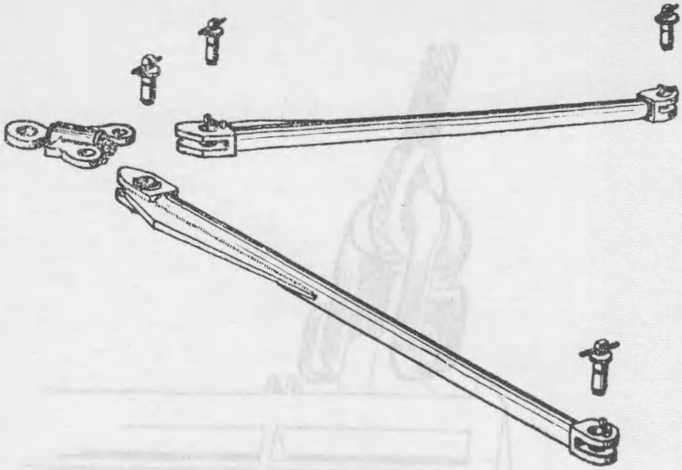


Figure 44 - Draw-bar

b. Violent steering of vehicles, especially tracked types, may place considerable overloads on draw-bars and cause buckling of the leg under compression. Steering with such a draw-bar in use must be gentle.

909. REFERENCES

Detailed operating and maintenance instructions for the Centurion ARV are contained in the User Handbook WO 12234 and EME Manual instructions, section J. A Crew Servicing pamphlet, issue 2 of 1959, also contains servicing instructions for the benefit of recovery personnel.

CHAPTER 10

THE RECOVERY TASK

SECTION 1 - ASSESSMENT OF THE TASK

1001. GENERAL

Each recovery task requires an appreciation before a plan can be devised. The aim, which may be the simple unditching of a wheeled vehicle or the more difficult recovery of a tank damaged by enemy fire, must be clearly understood and all the factors affecting its attainment must be taken into account before the plan is made. Junior leaders must be made familiar with the routine of appreciation, plan and execution of recovery tasks by practical examples.

1002. FACTORS

a. Each situation must be considered on its merits. The factors to be considered may vary with every recovery task but the following will usually be included:

(1) rolling resistance of the casualty, taking into account any damage it may have suffered;

(2) ground conditions affecting accessibility, use of holdfasts, direction of pull, etc;

(3) enemy activity which, for example, may make the use of an ARV desirable although a wheeled recovery vehicle would be adequate to move the casualty or which may make it essential for the recovery to be carried out during darkness;

(4) time and space will affect the choice of method, for example, if time is short it may be advisable to take risks rather than laying out elaborate tackles and distances to be covered may lead to the choice between towing or transporting;

(5) availability of recovery vehicles and equipment.

1003. THE PLAN

a. The plan may include such items as recovery vehicles, special apparatus to be taken (dependent on the magnitude of the task), spares which it is known will be required, personnel needed, method of recovery to be adopted and ration requirements.

b. It is imperative that all concerned in the operation know the full details of the plan as it affects them.

SECTION 2 - PRELIMINARY WORK

1004. GENERAL

A certain amount of preliminary work before using a recovery vehicle and its equipment will frequently reduce the effort required in extricating the casualty.

1005. DIGGING

a. Soil obstructing the passage or free movement of a vehicle casualty should be removed. Figure 45 (a) shows a vehicle stranded as a result of running off the road and ditching the near side wheels. The whole of the near side suspension and the rear axle have become embedded in the grass verge. A winch pull applied to the vehicle as it stands is likely to strain the rear axle and cause damage. The ground should first be dug away as shown in Figure 45 (b) to give the axle and suspension the required clearance and to give a slope for the near side wheels.

b. Soil removed must be thrown clear of the casualty and not deposited in the path over which the casualty is to be hauled. Care should be taken to conceal fresh soil from air observation. When digging near roads, all loose soil on the road must be removed and any gaps made in the verge or curb must be filled in so that other traffic will have no difficulty in following the edge of the road in fog or at night.

Figure 45 - Ditched Wheeled Vehicle

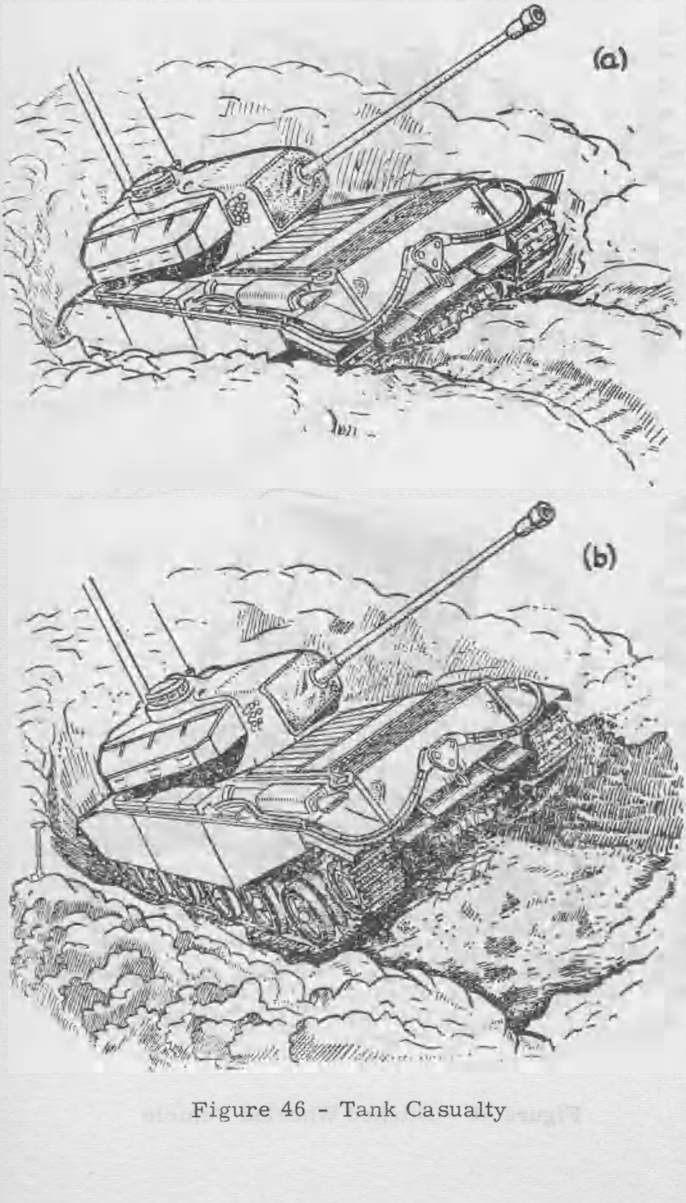


Figure 46 - Tank Casualty

c. It is often advisable to dig a slope in order to reduce the grade resistance offered by a casualty. Figure 46 (a) shows a tank trapped in a hole and Figure 46 (b) illustrates the result of digging, first to release it and secondly to provide a slope up which it may be hauled.

d. Digging is sometimes required to uncover the point for attachment of a rope to the casualty. The time taken in digging underneath the casualty in order to connect a belly-pull is often well spent.

1006. USE OF GUN-PLANKS AND ROLLERS

a. Laying a flooring of gun-planks will form a firm path over which an equipment casualty may be hauled.

b. Rollers require a smooth flat surface above and underneath them and thus their use in recovery is limited but in certain circumstances they can be applied to reduce rolling resistance. It must be remembered that the load will move twice as fast and twice as far as the rollers underneath it so they must be laid well in advance of the casualty.

1007. CLEARANCE FOR RECOVERY EQUIPMENT

Recovery equipment such as snatch-blocks may become buried in the ground and their moving parts clogged up with earth. Figure 47 shows how judicious digging and the use of skids or gun-planks will prevent this occurring.

1008. REPAIRS TO THE CASUALTY

The execution of repairs, even temporary repairs, to the casualty will frequently speed up recovery by reducing the resistance due to damage. The time and effort spent repairing a track, for example, may result in a quicker job than would result from laying out complicated tackles.

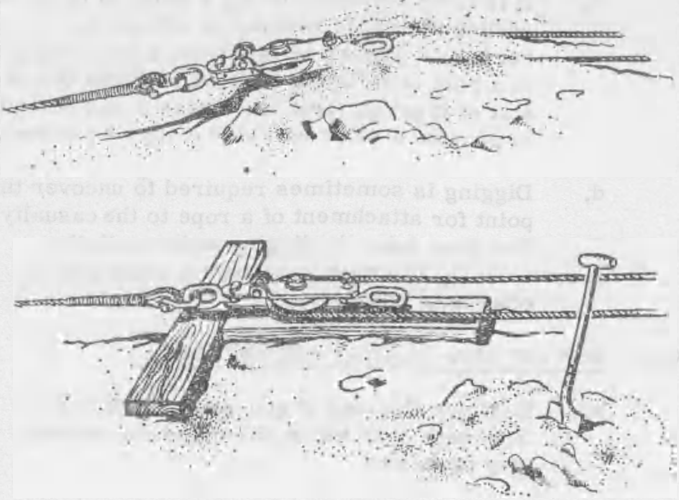


Figure 47 - Use of skidding

1009. CALCULATION OF THE LOAD

a. When the resistance to motion of the casualty has been estimated a decision can be made whether a tackle must be used and, if so, what arrangement will be necessary. In the extrication of an equipment three main problems are usually encountered:

(1) moving the casualty for a short distance onto better ground;

(2) righting a casualty which is lying on its side;

(3) turning end-over-end a casualty lying upside-down in a tank trap or one which has rolled down a steep embankment.

b. Resistance to motion when pulling or winching the casualty has been dealt with in Chapter 4, Section 6.

c. When a vehicle is lying on its side, it has been found that a pull equal to approximately

half its weight is required to put it back on its wheels or tracks. In practice it is advisable to increase this figure by 25 percent to allow for unknown factors, so the pull is estimated as five-eighths of the weight of the vehicle.

d. The pull required to turn end-over-end a vehicle lying upside-down has been found in practice to be approximately equal to the weight of the vehicle if there is an initial tilt of 25 degrees in the direction of the pull. To allow for unknown factors, an extra 25 per cent is added, so the total pull required is estimated as one and one-quarter times the weight of the casualty.

SECTION 3 - EXTRICATING THE CASUALTY

1010. SIGNALS USED DURING RECOVERY

In order to co-ordinate the efforts of a recovery crew a system of signals for the transmission of orders has been devised. Annex F sets out this standard code of signals.

1011. APPLICATION OF FORCE

a. The power of a recovery vehicle can be applied in four ways:

(1) by towing,

(2) by pushing, using a nosing prop,

(3) by pulling with a winch,

(4) by hoisting or lifting.

1012. USE OF RECOVERY VEHICLES SINGLY AND IN PAIRS

a. The employment of a single recovery vehicle is preferable because it is difficult to control two or more recovery vehicles simultaneously. If one of them takes more than its proper share of the load it will throw the

operation off balance but with careful control recovery vehicles can be worked in pairs as follows:

(1) to lift a casualty;

(2) to provide a winch pull with one and a check pull with the other when righting a casualty;

(3) to use one for winching and the other for anchoring either the winching vehicle or the tackle.

b. If the winch of one recovery vehicle is not sufficiently powerful for a task then a tackle should be used and not the additional pull from a second recovery vehicle. Two (or more) recovery vehicles can however be used in tandem to produce a combined draw-bar pull. In this case careful control of the drivers is essential to ensure that the load is evenly distributed.

1013. TURNING A CASUALTY

a. It is often necessary to turn a non-runner vehicle not only when extricating but also when loading or unloading from a transporter or railway flatcar. The required movement may be quite small or may involve a complete turn of the vehicle.

b. When on hard standing the use of the nosing prop referred to in Chapter 6, Section 3 is ideal, provided that the recovery vehicle used is suitably fitted for this purpose.

c. For tank casualties the method illustrated in Figure 48 is simple and effective. A three foot skid is jammed under the track which is to be the centre of rotation. The other side of the tank is pulled towards the side with the skidding as shown in Figure 48 (a). The off-side track in this case will rotate in the direction indicated by Arrow B. Movement continues until the skidding becomes free and drops away from the track as indicated in

Figure 48 (b). Although a number of separate movements is required to turn a tank through 90 degrees, each movement is relatively quick and simple to perform. Forward movement of the tank is very slight and this method may be used to turn a non-runner tank in a confined space.

1014. BELLY-PULLS

When a tank casualty is being winched up a steep slope it is usually better to have the rope passed under the belly of the tank and attached to the rear. This arrangement will prevent the front of the vehicle digging into the slope because the pull tends to lift it. Plate 7 shows a tank casualty being winched up a slope and illustrates the method by which it is prevented from rising too steeply at the foremost end when on the brow of the slope. The tow-rope is attached to the rear towing eyes and passed underneath the belly of the tank while another rope is passed under the tow-rope and shackled to the front towing eyes to act as a check-rope.

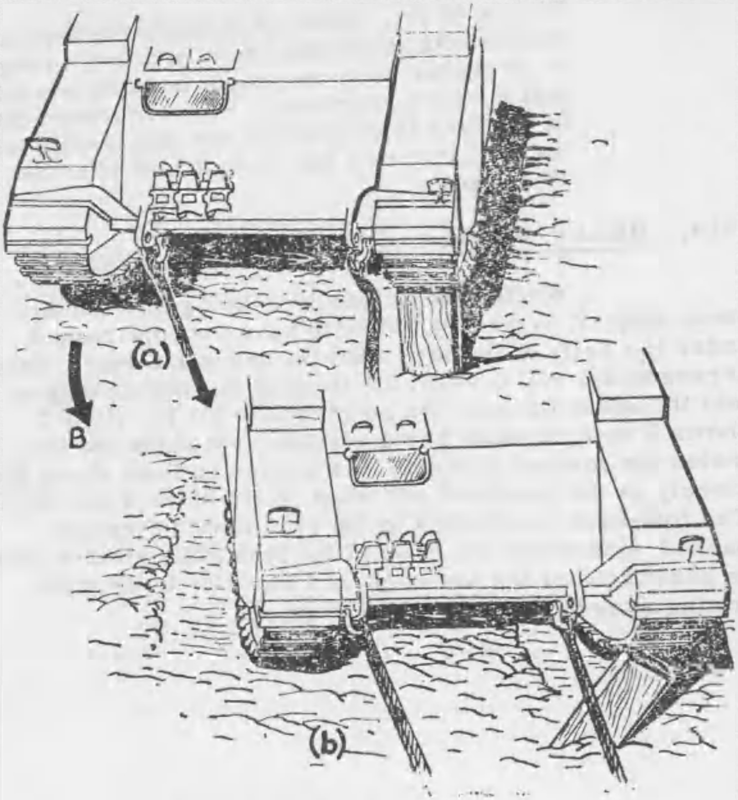


Figure 48 - Turning a tank

1015. PROTECTION OF EQUIPMENT

a. During the process of extrication, damage can be inflicted on a casualty by the careless application of recovery equipment. This is particularly true when using wire ropes or slings.

b. Protruding and accessible parts must not be assumed to be sufficiently strong to withstand a winch pull. For example, the turret of a tank might appear to be a suitable anchorage, especially if the vehicle is partly submerged in water or swamp, but on no account should it be so used. The bearings on which the turret is carried are not designed to withstand such a pull. Again, a

rope intended to right an overturned truck must never be passed around the cab.

c. It should be borne in mind that the higher a horizontal pull is applied, the greater will be the tendency to thrust the leading end of an equipment downwards.

d. Winch ropes or tow-ropes should always be anchored to attachment points provided for the purpose; if these are buried, they must be uncovered by digging.

e. Precautions against damage to tanks include the use of skidding and sand bags. These are placed to prevent ropes from bearing on weak points such as track guards which are particularly prone to damage. Care must be taken to avoid damage to bogies, sprockets and the tank armament.

f. The tracks, if slack, should be tied to the bogies to prevent them from slipping off during righting operations. A track slipping off will cause delay, especially if no transporter is available and the casualty has to be towed away.

g. Precautions against damaging wheeled vehicles which have overturned include:

(1) The cargo must be unloaded before attempting to right the vehicle.

(2) The sides of wheeled vehicles should be protected against crushing. Figure 49 shows how rollers can be placed between the side of the body to act as struts while gun-planks and skidding at the ends of the rollers distribute the load.

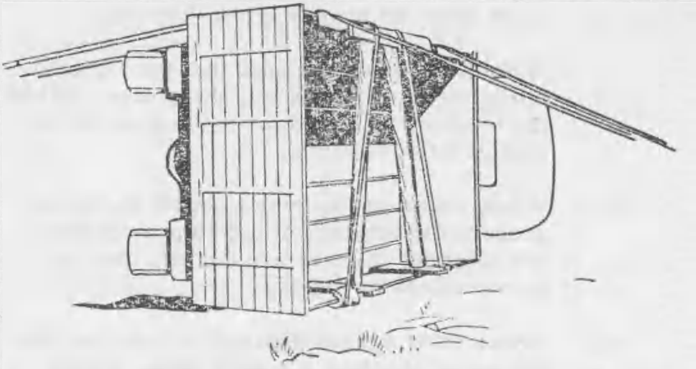


Figure 49 - Prevention of damage to wheeled vehicle body

h. Figure 50 illustrates a wheeled vehicle on its side. The most suitable parts for rope attachment are heavily outlined and indicated by the numbers 1 to 5 while other less substantial components to which attachment must NOT be made are numbered 6 to 9. The chassis side members will safely take a rope pull when they are evenly loaded but uneven and offset loads tend to distort the frame.

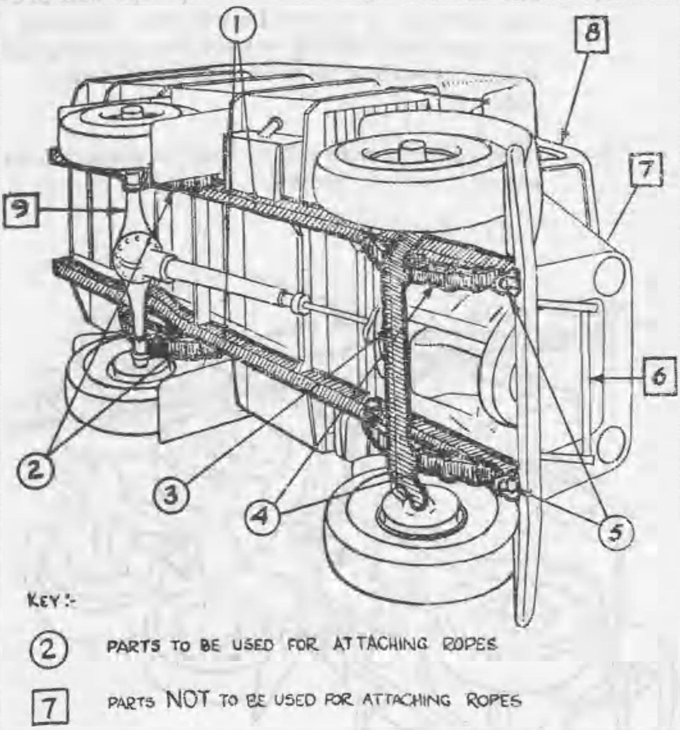


Figure 50 - Rope attachment points, good and bad

1016. CHECK-TACKLES

a. In addition to the pull required to right an overturned casualty, a steadying pull in the opposite direction is needed so that after the point of balance is reached the equipment can be lowered gently onto its wheels or tracks. This pull is provided by a check or steady tackle.

b. Figure 51 shows how the ropes should be attached to the chassis of an overturned vehicle. By careful positioning of the winch ropes and steady ropes the resultant of the opposing pulls can be kept to a minimum thereby avoiding distortion of the chassis frame.

c. The use of large sizes of hemp rope will prevent damage to external surfaces. Skidding and sand bags should be used for rounding off sharp corners to prevent chafing of hemp ropes.

d. Wire ropes should not be used in contact with wheeled vehicle bodies.

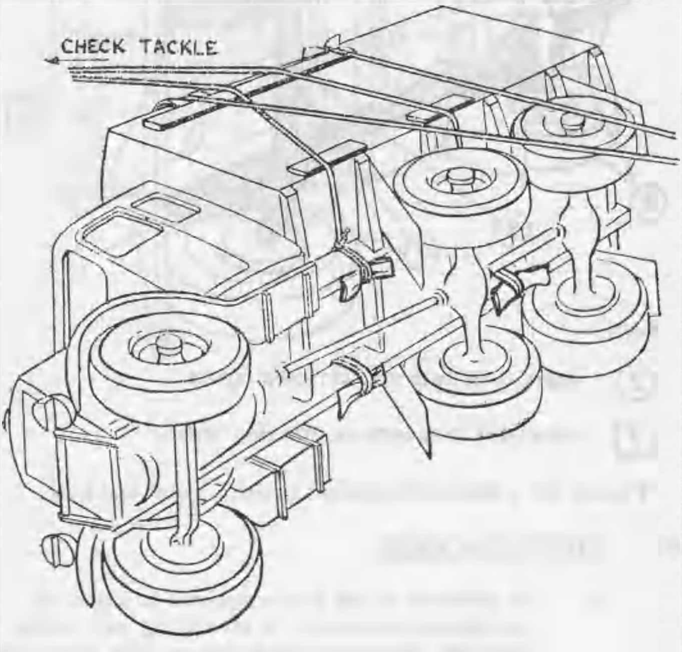


Figure 51 - Check-tackle applied to a wheeled vehicle

1017. WINCHING

a. While recovery vehicle winches vary in design, construction and performance, they have certain operating principles in common:

(1) A winch rope should always be led off or winched on at right angles to the axis of the drum to avoid friction of the rope in the fairlead and the imposition of undue

loads on the winch itself. This is equally important on a winch with no fairlead if the rope is to wind evenly on the drum.

(2) The maximum pull is developed by the winch when there is one layer of rope on the drum. As the number of layers increases, the effective diameter of the drum increases and so the maximum winch pull decreases.

(3) When applying a check-pull, the winch rope should be paid out under power if possible. Alternatively the winch should be kept in gear and controlled with the winch brake.

CHAPTER 11

PREPARATION FOR TOWING AND TRANSPORTING

SECTION 1 - GENERAL

1101. METHOD OF BACKLOADING

If a vehicle casualty cannot be made a runner after it has been extricated, it must be backloaded either by towing or transporting.

1102. WINCHING A CASUALTY OVER DIFFICULT GROUND

a. When a casualty is being towed by a recovery vehicle fitted with a winch and difficult ground is encountered, it is advisable to detach the casualty and, having connected the winch rope to it, drive towards firmer ground paying out the winch rope behind.

b. When firm ground is reached the recovery vehicle will be in a position for winching-in the casualty. It may be necessary also to put out an earth anchor.

1103. LIMITED USE OF TRANSPORTERS OVER BAD GROUND

Transporters must be loaded on firm ground. An unloaded transporter will stand on fairly soft ground without sinking but on the same ground it may sink to the axles when loaded. The casualty must therefore be moved well clear of bad ground before attempting to load it on to a transporter.

1104. LIMITED USE OF ARMOURED RECOVERY VEHICLES OVER GOOD GROUND

a. ARVs are designed for use on difficult ground. After extrication a casualty should be towed by such vehicles no further than is absolutely necessary prior to loading on a transporter or being towed by a wheeled vehicle.

b. The movement of all heavy tracked vehicles on roads should be restricted due to the

amount of damage they may do to the surface and due to the high rate of wear of the tracks.

1105. MAKING VEHICLE CASUALTIES MOBILE

a. When a vehicle is immobilized by such causes as enemy action, accident or mechanical failure, it may be necessary to carry out certain repairs or adjustments so that it can be moved with safety. Such repairs or adjustments may allow the vehicle to proceed for a limited distance under its own power but more often than not they are essential either to enable the wheels or tracks to run or to prevent further damage.

b. Wheeled vehicle casualties may be dealt with as follows:

(1) Engine Failure. The gears must be in neutral for a straight tow.

(2) Transmission Seized or Damaged. The propeller shafts are removed for a straight tow.

(3) Broken Axle Shaft. For vehicles with semi-floating or three-quarter-floating axle shafts a rear suspended tow is required. Alternatively the rear of the casualty may be secured on top of a trailer. In either case it is necessary to lash the steering. For vehicles having fully-floating axle shafts it is necessary to remove the hub cap and withdraw the broken shaft. The hub cap is then replaced and a straight tow is possible.

(4) Wheels Blown Off. This type of casualty usually includes damaged axles and springs. Backloading is effected by a trailer-supported tow. Vehicles damaged badly at both front and rear ends must be loaded onto a trailer for transportation.

c. Tracked vehicle casualties are dealt with in a somewhat different manner from wheeled

vehicle casualties since towing must be restricted as explained in paragraph 1104 b. As the limitations for movement on roads apply to any heavy tracked vehicles all casualties of such a nature requiring long distance backloading by road must be carried on transporters. Some methods of dealing with tracked vehicle breakdowns are:

(1) Engine Failure. By a straight tow with gears in neutral, or by transportation.

(2) Transmission Seized or Damaged. The final drive must be disconnected from the gearbox for a straight tow.

(3) Suspension Unit Seized. The suspension unit must be jacked up and held clear of the track. The vehicle can then be driven off under its own power.

(4) Final Drive Seized. On many tracked vehicles the track may be shortened so as not to pass over the final drive sprocket. The casualty may then be towed. If the ground is firm the track may be removed completely and the vehicle towed on its road wheels.

d. Methods of shortening Centurion tank tracks to make the vehicle mobile are detailed in Annex G. Further detail is continued in EME Manual Vehicles J 289 Instruction 18.

e. In recovering tracked vehicle casualties it is often far better to carry out repairs on the spot rather than to attempt to backload a dead vehicle. Examples of work which may be done in situ are as follows:

(1) Track Damaged by Mines or Gunfire. Replace sections of damaged track to allow the vehicle to proceed under its own power.

(2) Final Drive Seized. Remove and replace this assembly when practicable with the use of a turret boom.

(3) Jammed Track. Break the track by oxy-acetylene gas cutting or the use of an explosive charge. The track may then be replaced completely or new sections inserted.

SECTION 2 - TOWING WHEELED CASUALTIES

1106. METHODS

a. The three principle methods of towing wheeled casualties are straight, suspended and supported tow.

b. In practice, wheeled casualties are usually towed by wheeled vehicles but in an emergency an ARV may be employed. ARVs are not designed to give a suspended tow and though some types have rear lifting frames they should not be used for suspended towing over long distances.

c. When towing in Canada the following practice is recommended: (elsewhere, units will conform to local orders on the subject.)

(1) If a tow-rope is used its length should not exceed 15 feet and a white rag should be tied in the centre to help the driver of the casualty to see when the tow-rope is taut.

(2) The words "ON TOW" should be clearly chalked or otherwise prominently displayed at the rear of the towed vehicle.

(3) The speed of both vehicles should not exceed 15 miles per hour.

d. A licensed driver must accompany a towed vehicle if such vehicle is not in suspension.

1107. STRAIGHT TOW

a. The normal method of effecting a straight tow is by rigid attachment between the vehicle casualty and the recovery vehicle. This is known as rigid tow and is preferable to a rope

tow because it requires less skill from both drivers.

b. The various types of apparatus for rigid towing and the methods for attachment are described in Chapter 9.

c. Rope tow is an emergency method of straight towing which imposes the necessity for strict precautions against danger to other road users and damage to both vehicles. Besides ensuring that the recovery vehicle is capable of drawing the combined load the following practices are necessary:

(1) The tow-rope must be correctly attached to the towing attachments or if these have been rendered useless made fast to the chassis side members. Two ropes should be used for a heavy or difficult tow.

(2) During the towing operation careful control must be exercised to:

(a) avoid damaging either tow ropes or vehicles and see that the slack rope is taken up without snatch, both when moving off and while travelling;

(b) ensure that proper use is made of the prearranged system of signals between the drivers of the two vehicles; visual signals can be supplemented by horn signals as an immediate warning to either driver to stop.

1108. SUSPENDED TOW

a. Where it is necessary to tow a wheeled vehicle having the front or rear wheels or suspensions inoperative, the quickest and easiest method is by suspended tow. There are, however, limitations when using a recovery vehicle for this purpose since:

(1) the rear suspension of the vehicle must not be overloaded;

(2) the weight of the suspended casualty tends to lift the front wheels of the recovery vehicle causing some loss of steerage, particularly on gradients;

(3) the lifting gear and the structure of the vehicle may become damaged.

b. It is imperative therefore, to ensure that the axle weight of the casualty at the damaged end is within the permissible load limits of the recovery vehicle, as well as to ensure that the latter is powerful enough to pull itself and the casualty.

c. Figure 52 shows a vehicle in a suspended tow. The damaged end of the casualty is hoisted by the tackle of the recovery vehicle so that the wheels are at least six inches clear of the road surface. The tackle is then secured for travelling.

d. The general principles employed in front suspended tow apply to rear suspended tow except that:

(1) The driver must NOT be allowed to sit in the cab and attempt to steer the casualty. Sufficient control is impossible.

(2) The steering gear of the casualty must be securely lashed.

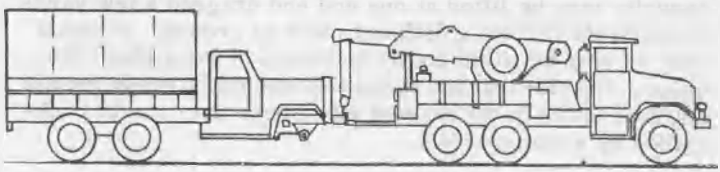


Figure 52 - Suspended tow

1109. SUPPORTED TOW

a. If a heavy wheeled vehicle receives extensive damage to the rear or front end and the axle weight is too great for a suspended tow, the most satisfactory solution to the problem of

backloading is to load it on to a trailer. However, heavy trailers are not always available for recovering wheeled vehicles and a smaller trailer can be used to support the damaged end of a casualty vehicle although it may not be strong enough to take the weight of the whole vehicle.

b. The problem of raising the damaged end of the casualty and inserting the trailer between it and the recovery vehicle may be solved by lifting the damaged end with the boom and tackle of a recovery vehicle positioned at right angles to the casualty and pushing the trailer underneath. A second recovery vehicle or a mobile crane may also be useful for lifting.

c. As with other methods of towing, it must be ensured that the recovery vehicle is capable of drawing both itself and the casualty. Furthermore, in the case of rear supported tows, the precautions laid down in paragraph 1108 d must be taken.

SECTION 3 - TOWING TRACKED CASUALTIES

1110. GENERAL

The straight tow is the only practicable way of moving a tracked vehicle casualty from one place to another if a transporter cannot be used. Certain ARVs are fitted with a rear lifting device by which a tracked casualty may be lifted at one end and dragged a few yards to extricate it from a difficult piece of ground. A small vehicle may be lifted bodily and carried for a short distance. Heavier tracked casualties should be made mobile and then towed to the nearest site where they can be backloaded by a transporter.

1111. RIGID TOW

a. The draw-bar described in Chapter 9, Section 3 is used for the rigid method of towing which has a great advantage over a rope tow since control over the movements of the casualty is possible whether its steering is operative or not.

b. When negotiating a sharp turn, however, abnormal stresses are imposed on the draw-bar since the rear end of the recovery vehicle swings outwards against the resistance of the casualty. It is essential therefore to avoid sharp turns and never to attempt a neutral turn or a skid-turn standing still.

c. Another disadvantage of the draw-bar tow is the limitation of movement in the vertical plane. If an attempt is made to negotiate a sharp gradient such as depicted in Figure 53 the result would almost certainly be a cracked or broken draw-bar or towing eye. In such circumstances therefore, action should be taken to surmount very steep gradients or obstacles by changing to a tow-rope or by winching the casualty up the gradient or over the obstacle.

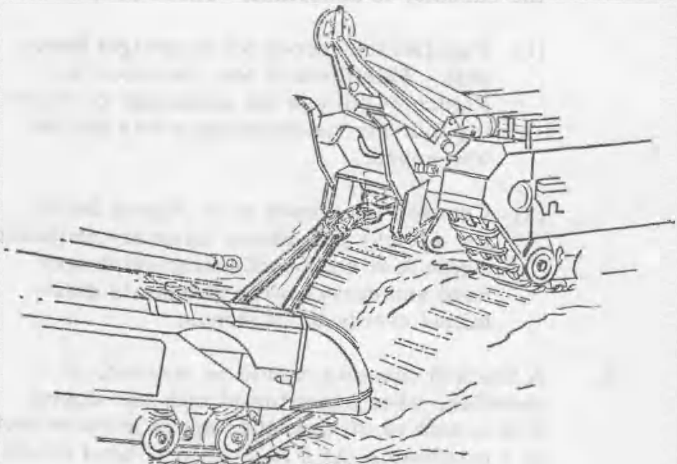


Figure 53 - Incorrect use of draw-bar

1112. ROPE TOW

a. Towing tracked vehicle casualties by means of tow-ropes has only one advantage over the rigid towing method, ie there is practically no limit to movement in the vertical plane. There are several disadvantages. The casualty tends to run in a straight line and downhill

it may overrun the recovery vehicle. The casualty must have a driver and the steering and braking arrangements must be operative.

b. The normal method of attaching a tow-rope to a tracked vehicle, as shown in Figure 54 (a) is known as an A-rope tow. It makes use of the link at the middle of a two-legged tow-rope for attachment to the rear central towing connector of the ARV, the snatch-hook ends of the legs being attached to the towing plates of the casualty by shackles.

c. This is probably the best form of tow-rope attachment for negotiating curves and bends but weaknesses in the towing connectors and in the tow-ropes themselves have led to the adoption of two other forms of tow-rope attachment for use when the tractive resistance of the casualty is abnormal. These are:

(1) Parallel tow-ropes for a straight heavy pull. This form of tow, depicted in Figure 54 (b) has the advantage of utilizing four strong attaching points for the tow-ropes.

(2) Crossed tow-ropes as in Figure 54 (c) for a heavy pull where turns are necessary. Again four strong attaching points are used and during turns tension is maintained evenly in the ropes.

d. A tracked casualty should be steered, if possible, when being towed with tow-ropes. If it cannot be steered then speed must be kept at a minimum. At a right-angled bend it will be necessary to use one of the methods described in paragraph 1013.

e. If the brakes of a tracked vehicle are inoperative it is necessary to provide a braking tank behind the casualty to provide adequate control. Such a tank is coupled to the rear of the casualty by means of a tow-rope and the driver will endeavour to keep his speed the same as that of the recovery vehicle with the help of a lookout man to signal when it is necessary for

the driver of the braking tank to apply his brakes.

f. When a tracked vehicle is under tow the strictest control must be exercised. This includes the continuous scrutiny of tow-ropes, shackles and snatch-blocks, which tend to open up and the correct use of signals.

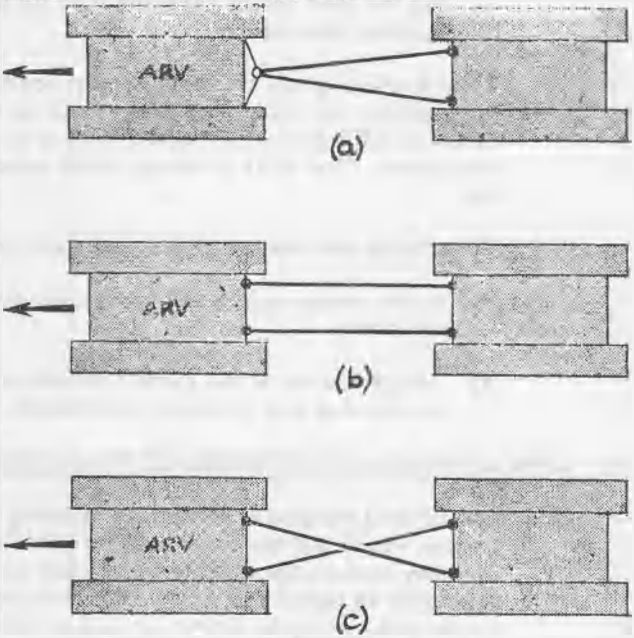


Figure 54 - Attaching tow ropes to a tank

1113. TOWING UP A PAVED SLOPE

If, in an emergency, an ARV has to tow a heavy casualty up a steep gradient on a paved road and it is found that the tractive effort is insufficient through track slip, a recovery vehicle should be anchored at the top of the slope to provide a winch pull.

SECTION 4 - TRANSPORTATION BY ROAD

1114. GENERAL

a. Vehicles used for transporting equipment casualties vary in construction and in

facilities for loading and off-loading but there are two fundamental principles in their operation:

(1) Loading and unloading must take place on firm level ground.

(2) The transporter must be capable of bearing the load and of carrying it to its prescribed destination.

b. When a transporter trailer has been positioned for loading, the vehicle casualty must be very carefully aligned with it before loading is attempted. The NCO in charge must ensure that:

(1) tractor and trailer brakes are fully on;

(2) where trailer jacks are used, they are in position;

(3) ramps are down and guide brackets on top decking are correctly positioned.

1115. LIVE LOADING AND METHODS OF UNLOADING

a. The normal method of loading is by using the tractor winch and tackle to pull the vehicle casualty up onto the deck of the trailer as described in paragraph 1116. The vehicle casualty may only be driven on to the trailer in a case of urgency and if it has full braking and steering facilities. This procedure is dangerous because the vehicle rears sharply up the trailer ramps, making control difficult. Furthermore some heavy tracked vehicles overhang at the sides of some types of transporter trailers so that alignment must be accurate to a matter of inches, otherwise the casualty may slip off the trailer.

b. The same principle applies to unloading. A casualty should only be driven off a trailer in an emergency. The two ways of unloading non-runners depend on the type of transporter used:

(1) If unloading is from a flat decked trailer, the casualty may be pulled off by winching.

(2) If unloading is from a sloping decked trailer, the casualty may be allowed to roll off under the control of the check-tackle.

In either case a check-tackle must be used to avoid damage to the tank as it leaves the trailer.

1116. DEAD LOADING OF TRACKED VEHICLES

a. A casualty with an unserviceable engine must be winched onto the transporter trailer by means of the transporter winch, adopting the principles and precautions laid down above. It is emphasized that very careful alignment of the casualty with the transporter tractor and trailer must take place before winching.

b. Since the casualty must be pulled up the slope of the trailer ramps and possibly up a sloping deck, it imposes a resistance to motion greater than the transporter winch can handle. The extent of this resistance is calculated as described in Chapter 4, Section 6 in order to determine what tackle should be used.

c. The tackle should be arranged so as to provide a belly-pull to the casualty to enable the front end of the casualty to ride onto the ramps more easily with a check-rope to stop the front end rising too much at the top of the ramps. The tackle block beneath the casualty should be positioned as far to the rear as possible to obviate closing up of the tackle before the haul is completed. In this case the front check-rope is dispensed with and skidding is placed behind the ramps to reduce the sharpness of the slope.

d. When winching the casualty onto the transporter strict control must be exercised. The operation should be done slowly and frequent inspection made to check alignment. Ensure

that the moving snatch-block does not foul the trailer cross members. If the alignment is incorrect, stop the operation, re-align and start again.

1117. FINAL CHECKS AFTER LOADING

a. Before moving off, careful inspection should be made to ensure that:

(1) the trailer is properly and safely connected to the tractor;

(2) braking and lighting connections are properly made;

(3) the casualty is properly secured with its brakes on, all chocks in position and all chains and tensioners tight;

(4) all jacks have been removed or stowed;

(5) parking brakes are off;

(6) tire pressures are correct.

b. After the first few miles the securing gear should be tightened.

SECTION 5 - TRANSPORTATION BY RAIL

1118. RESPONSIBILITY

Recovery work sometimes includes loading and unloading equipments at railheads. The work is normally a function of army recovery companies. While the staff of Q (Movements) is responsible for the proper distribution and securing of loads on rolling stock, the actual securing of the loads is done by recovery vehicle crews.

1119. ENTRAINMENT AND DETRAINMENT OF WHEELED EQUIPMENT

Loading wheeled equipments on to flat cars from a fixed ramp or platform or side-loading from a platform can be achieved either under power, by towing with a tractor or manually by pushing. In some cases, with severly damaged equipments, railway cranes are used for

lifting into freight cars or on to the flatcars. Unloading techniques are similar.

1120. ENTRAINMENT AND DETRAINMENT OF TRACKED VEHICLES

a. Entrainment of tanks and other tracked equipments may be done in order of suitability as follows:

(1) end-loading from an end-loading platform or permanent end-loading ramp;

(2) side-loading from a freight or passenger platform.

The decision as to which method should be used depends on factors such as urgency, accessibility, available cover and degree of interference with other traffic.

b. Detrainment of tanks and other tracked equipments is carried out by using the same facilities as for entrainment and depends on the same factors. In addition, detrainment can be effected by use of emergency ramps or sleepers.

c. End loading platforms are generally used for loading wheeled vehicles and are normally suitable for tracked vehicles. The practice is to load direct from platform to flatcar filling the train from front to rear.

d. Any suitable platform is used for side-loading and some platforms are sufficiently long to entrain several tracked vehicles at the same time by swinging direct from the platform to the flatcar. When loading in this manner care should be taken to:

(1) approach the flatcar deck at an angle of 30 degrees to save unnecessary manoeuvring.

(2) swing all tracked vehicles to face the same direction along the train and, while

swinging, to avoid any adjacent siding or main line.

Side-loading is not a suitable method for loading dead tracked vehicles.

e. Emergency unloading using stacked sleepers may be necessary if the train or ramp is damaged and a serviceable ramp is not available. Direct descent from a flatcar to ground level would damage the suspension of the vehicle, but the following methods have been tried with success:

(1) End-unloading over a pile of 70 sleepers.

(2) Side-unloading on to a pile of 20 sleepers stacked not less than 2 feet high and five feet from the side of a flatcar. If sleepers are not available hay bales, straw, rubble, etc, can be used instead.

1121. <u>LOADING DEAD TRACKED VEHICLES</u>

a. From an end-loading platform the problem of loading or unloading dead tracked vehicles is easier when such casualties can be mixed with live ones. The principle to follow is to load a dead tank between two live ones so that loading or off-loading may be accomplished by towing. Where this is not possible, a tractor moving on one side of the track can tow the dead vehicle along the flatcars by use of a tackle, the block being anchored to the leading flatcars. If only limited movement is possible at the side of the track, the winch of a stationary recovery vehicle may be used to do this.

b. In loading from rail level by means of a ramp, a dead tracked vehicle must be winched up the ramp. A recovery vehicle at the trackside will use winch and tackle through a block anchored to the front end of the nearest flatcar.

CHAPTER 12

SELF-HELP AND EXPEDIENTS

SECTION 1 - GENERAL

1201. When an undamaged vehicle becomes immobilized through bad ground conditions every effort must be made towards self-recovery, making use of the power of the vehicle itself. A recovery crew in particular should always be able to extricate its own vehicle without additional help.

1202. Most methods of self-recovery are straightforward but some situations call for ingenuity and the ability to improvise. Some of the principles and methods used in self-recovery may, on occasions, be applied to the extrication of a dead vehicle.

SECTION 2 - SELF-HELP AND RECOVERY

1203. THE RECOVERY VEHICLE WINCH FOR SELF-RECOVERY

a. The recovery vehicle winch may be employed for self-recovery as well as recovery of another vehicle. Recovery vehicles equipped with rearward-pulling winches are usually provided with the means of making a forward winch pull.

b. The winch rope is paid out either to the front or the rear and fastened to a sufficiently strong anchorage. The vehicle should then be able to pull itself forward or backwards and extricate itself.

c. Side pulls should not be attempted in self-recovery except when a ditched vehicle may be freed fairly easily by a winch pull slightly out of line.

1204. OVERALL AND NON-SKID CHAINS

a. Chains, overall or non-skid of one type or another, are available in appropriate sizes to suit the majority of wheeled vehicles.

b. This equipment should be fitted before trouble is likely to be encountered. In conditions where a wheeled vehicle has sunk fairly deeply in mud, bog, or snow, the subsequent application of chains will generally aggravate the situation by churning away the soil with no helpful effect.

c. Chains are intended solely to increase the grip of the wheels under adverse conditions. The selection of the right time for fitting overall and non-skid chains calls for good judgement and the task of fitting the chains demands skill. Tires can be seriously damaged as the result of incorrect fitting and use of chains which can also cause undue wear and damage to chains themselves.

1205. TYPES OF CHAIN

a. The following are two types of chains which may be used in recovery:

(1) Overall chains are provided for use with pairs of driving wheels in tandem. The chains are fastened round two wheels as an endless belt, see Figure 55. They are also suitable for use with twin wheels and are made with two types of shoe:

(a) Smooth soleplate or packflat chains are designed to increase the bearing area of the wheels. The smooth soleplate type of shoe is shown in Figure 56 (a).

(b) The spiral shoe is shown in Figure 56 (b). Due to their comparatively sharp section this shoe is able to bite into the ground more deeply than a rubber tire whatever its tread may be.

(2) Non-skid chains are the light and simple type of non-skid chains used on cars and other light wheeled vehicles. They are made from standard commercial chain. Larger and more complex chains, an example of which is shown in Figure 57,

are provided for heavy military vehicles. Non-skid chains are made for both single and twin wheels.

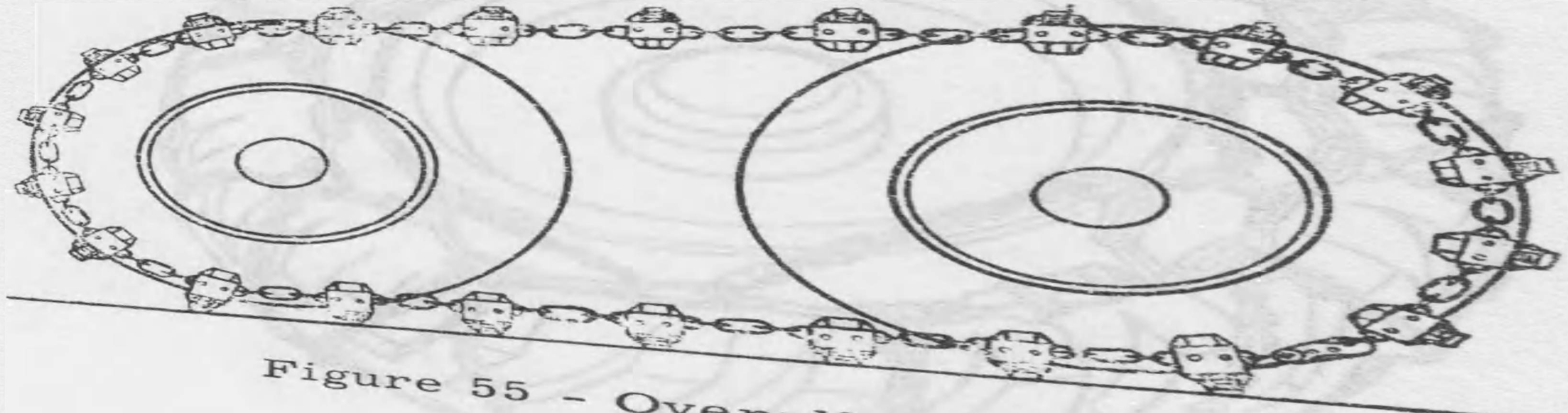
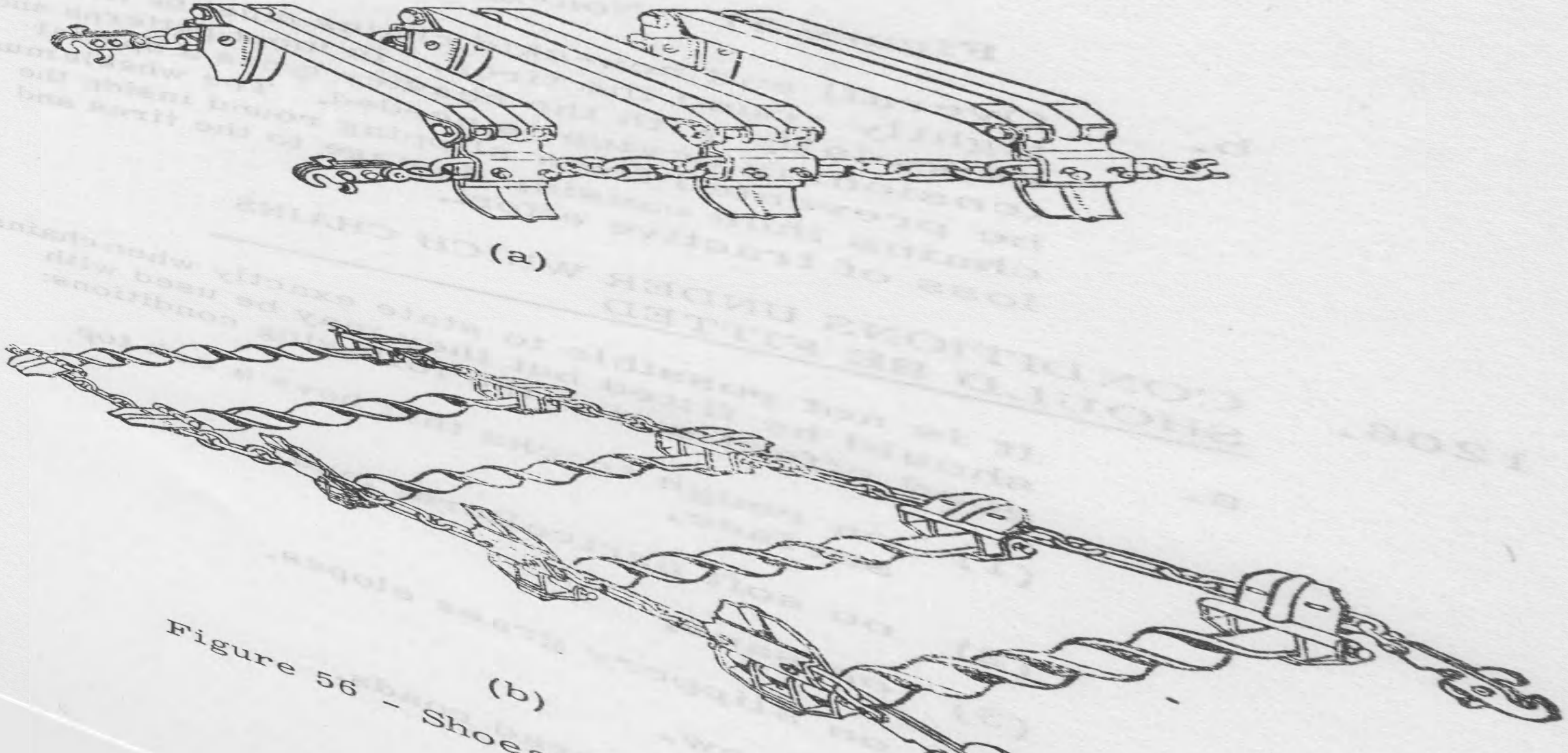


Figure 55 - Overall chains fitted



(a)

(b)

Figure 56 - Shoes-overall ch

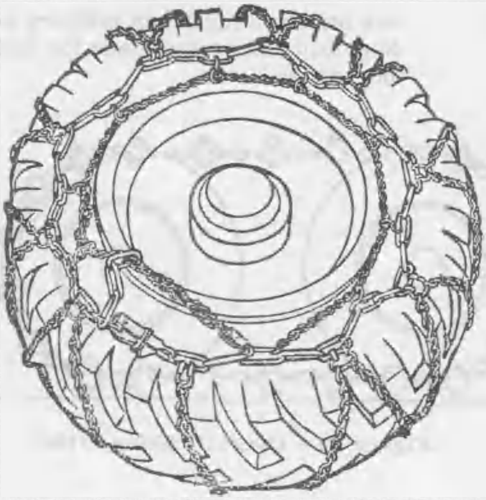


Figure 57 - Non-skid chains

b. Overall and non-skid chains must be fitted tightly round the tires. In most patterns and especially with the heavier types a special tensioning device is needed. The wheels must be prevented from slipping round inside the chains thus causing damage to the tires and loss of tractive effort.

1206. CONDITIONS UNDER WHICH CHAINS SHOULD BE FITTED

a. It is not possible to state exactly when chains should be fitted but they may be used with good effect under the following conditions:

(1) on rough tracks that have a soft top surface,

(2) on soft agricultural land,

(3) on sand,

(4) on slippery grass slopes,

(5) in snow,

(6) on ice-covered roads.

1207. PRECAUTIONS WHEN USING CHAINS

a. When using chains care should be taken to:

(1) fit them in good time and remove them as soon as possible;

(2) remove them when traversing rocky terrain or hard surfaces except in the case of ice-covered roads;

(3) adjust and tension the chains correctly;

(4) maintain the correct tire pressures;

(5) keep vehicle speeds as low as possible;

(6) inspect tires and chains frequently to check damage and to take up any slack in the chains.

CHAPTER 13

SPECIAL TECHNIQUES

SECTION 1 - GENERAL

1301. In the foregoing chapters of this pamphlet emphasis has been placed on the need for speedy and efficient recovery. Recovery situations do not conform to a set pattern although there is a similarity between many of them. Thus some fundamental principles governing recovery techniques can be laid down but in warfare, where the need for speed and efficiency is paramount, flexibility in planning is essential.

1302. On some occasions it is necessary to combine repair with recovery and on others to take extreme measures such as removal of tracks by the use of explosives. Some of the techniques employed on battlefields are typical examples of flexibility in planning. When planning the recovery of drowned vehicles it may be necessary to modify preconceived principles to some extent.

SECTION 2 - BATTLEFIELD TECHNIQUES

1303. GENERAL

a. Speed of recovery is essential in battle. There will be occasions when safety of equipment and crew may have to be sacrificed to some degree when recovery is carried out close to the enemy. However, other arms may provide support and protection.

b. The ARV and recovery APC will normally be the vehicles used in these conditions and the techniques employed must be as simple as possible. Most often a straight tow to a position where the repairs can be carried out will be necessary to get the equipment back into action as soon as possible. There will be occasions when vital repairs may have to be carried out before a tank or APC can be moved or before it can move under its own power.

c. Recovery after the battle can be planned in detail and orthodox methods used as a full reconnaissance can be made of the equipment casualties. The use of helicopters may assist in this task. Risks need not then be taken in the use of the recovery equipment as speed is not of paramount importance. Some repairs will probably be necessary in all cases before the equipment can be moved.

d. Recovery personnel must be familiar with their formation instructions on the handling of personnel casualties and dead crews found in tanks. They must know the procedure for burial and the correct method for the disposal of personal effects referred to in Chapter 2, Section 8. They must have some knowledge of booby traps and how to tackle them and have knowledge of the location and lifting of mines. They must also know how to handle and dispose of live ammunition.

1304. USE OF EXPLOSIVES

a. Recovery personnel may have to use explosives for breaking a jammed track in an emergency or for the destruction of equipment in accordance with the formation commander's plan. Explosives can also be used to assist in the extrication of an equipment casualty by the destruction of an obstacle or an obstruction. In these circumstances the services of the RCE are required.

b. A jammed track must be cut by explosives if it cannot be freed by any other means and the tactical situation calls for speed as a principle factor affecting recovery.

1305. TACTICAL DESTRUCTION OF CASUALTIES

a. Field Engineering and Mine Warfare, Pamphlet No 3, Part I, Demolitions, 1953, (WO Code No 8776), Chapter 5 describes in detail how guns, tracked and wheeled vehicles may be destroyed. A SOLOG agreement entitled 'Procedure for Destruction of Military Technical Equipment' is being prepared for war in the United States, United Kingdom and

Canadian Armies. This agreement, when published, will authorize the priorities for destruction of parts of military technical equipments.

b. Most of the methods of destruction involve the use of explosives which may be issued to RCEME units for this purpose. Full safety precautions must be observed in their use, including keeping personnel at a safe distance from the demolition unless a slit trench or other shelter is available.

c. The following are among the methods which may be used for rendering equipment useless in the field:

(1) Guns:

(a) the removal of the breech block and sights;

(b) the destruction of the piece by explosives in the breech having blocked the first two or three feet of the bore;

(c) using the ammunition of the gun where bulk explosives are not available, eg one shell is inserted in the muzzle and a second complete with propellant charge is loaded into the breech; the gun is destroyed by firing it with its own mechanism using a lanyard of sufficient length to enable the firing party to keep well under cover.

(2) Tanks:

(a) by the detonation of a charge of 20 pounds of HE inside the hull after all hatches have been clamped down and all openings tamped solidly with sandbags.

(b) detonation of a similar charge placed against the turret ring and under the gun mantlet when it is not possible to enter the tank;

(c) destruction of the main gun as described above;

(d) destruction by fire when explosive charges are not available; pierce the fuel tanks and set the vehicle on fire.

(3) Wheeled Vehicles:

(a) wrecking the radiator, ignition system and crankcase by the use of a sledgehammer and the cylinder block, axles and chassis by one pound explosive charges; the fuel tanks should be pierced and the vehicle set on fire;

(b) draining the engine sump and radiator and running the engine at full throttle until it seizes and then setting fire to the vehicle.

SECTION 3 - BEACHES AND WATER CROSSINGS

1306. GENERAL

a. In beach recovery some special methods and techniques are necessary. This also applies to recovery work at water crossings. However, the principles laid down in this pamphlet are applicable in planning these operations. In particular the calculations given in Chapter 4, Section 6 for determining the resistance to motion of a casualty are valid provided some allowance is made for the effects of tides and currents.

b. The special techniques used in recovery on beaches and at water crossings which must be understood are:

(1) Wet Recovery. The recovery of equipment casualties from craft or from the water by waterproofed armoured recovery vehicles, sometimes assisted by amphibious vehicles.

(2) Dry Recovery. The recovery from the water's edge of casualties which have been recovered from craft or from the water.

1307. WET RECOVERY

a. Immersed equipment casualties must be recovered quickly. Frequently drowned equipments can only be worked on between tides and after each high tide the extrication may become more difficult. Tanks bogged hull-down in sand usually need bulldozers to dig them out before recovery vehicles can move them and sometimes a tank has to be lifted with a derrick to break the suction of the mud beneath it. Pumps may be needed to empty the water out of drowned vehicles.

b. One of the main problems of wet recovery is the provision of sufficient tractive force. Drowned or bogged vehicles, especially tanks, offer considerable resistance to movement which may be as high as 50 tons. Recovery vehicles are employed in accordance with their performance and suitability:

(1) special type ARVs for the recovery of tanks.

(2) amphibious recovery vehicles such as the DUKW for the recovery of wheeled vehicles, for rescuing the crews of drowned vehicles and for carrying repair parties to craft; DUKWs can also be used for taking out winch cables to drowned vehicles.

(3) heavy lift helicopters, when introduced, should be useful in this role.

c. During landing operations, a recovery vehicle should be stationed close to the ramp of the landing craft to deal with any vehicle which, by becoming a casualty, might obstruct the passage of vehicles following behind it. A recovery vehicle should also be stationed on the shore for winching purposes.

d. Similarly, a recovery vehicle should be placed at water crossings to deal with any immediate casualty. Vehicles prepared for fording should have their tow ropes in position ready for towing.

1308. DRY RECOVERY

Dry recovery on beaches is the removal of casualties, usually by towing from the water's edge, to drowned vehicle parks (DVPs) using pre-selected routes.

SECTION 4 - AIRCRAFT RECOVERY

1309. GENERAL

Problems encountered in the recovery of army aircraft are so numerous and varied that no fixed procedure has been established. Generally, recovery of aircraft by helicopter is preferred to recovery by vehicle due to locality, terrain, etc. Experience has proved that often more damage is incurred through recovery procedures than resulted from the accident itself, particularly when the aircraft was dismantled, loaded on a trailer and transported over rough terrain to the workshop site. Also, this is usually a time consuming operation. However, recovery should be carried out as quickly and efficiently as possible by whatever means available and in this regard supervisory personnel of recovery crews will require imagination and ingenuity in addition to their technical skill.

1310. RECOVERY BY HELICOPTER

a. Until such time as the army is provided with a helicopter capable of airlifting a fixed-wing aircraft or another helicopter, recovery will have to be by more conventional means.

b. The following practices, however, are related for the information of recovery crews:

(1) When such a helicopter as mentioned above becomes available and is used to recover fixed-wing aircraft, spoilers (pieces of wood, usually two inches by four inches, a little less than the length of each wing) must be attached to the top

side of the wings to prevent the air stream from flowing across them, thus eliminating the possibility of the recovered craft lifting itself toward the bottom of the helicopter.

(2) A light reconnaissance helicopter can be airlifted by other heavier type helicopters by using a cable attachment approximately three feet long with attaching rings on each end. The only parts which have to be removed are the main rotor blades from the blade grips and the mast retaining nut. A lifting eye is screwed on from where the mast nut was removed. One end of the cable attachment can be hooked through the lifting eye. The other end can then be used for hooking into the helicopter cargo sling hook. The cable will give sufficient clearance between the helicopter and load to help prevent accidents and enable the hook-up man to attach the load even though the helicopter is not directly over the hook-up point.

(3) A test lift should always be made to determine the centre of the gravity of the wrecked aircraft. If the craft tips nose down to a critical degree, weight should be removed from the forward section of the wreck or weight added to the aft portion.

1311. RECOVERY BY VEHICLE

a. Aircraft recovery by vehicle will be a matter for future study and until such time as a permanent technique has been evolved, the conventional methods will be used.

b. The following experiences have been proven, however, and are mentioned here for the benefit of recovery crews:

(1) When the wings or rotors have been removed from an aircraft casualty, a wrecker crane can be used to lift the fuselage onto a 2 1/2 ton truck.

(2) A small helicopter can be suspended behind a 5 ton recovery vehicle.

(3) In some circumstances the wings can be removed and manhandled onto a vehicle and the aircraft towed backwards behind a 1/4 ton vehicle with the tail wheel clamped to the back of the vehicle.

CHAPTER 14

CARE OF EQUIPMENT

SECTION 1 - GENERAL

1401. MAINTENANCE

a. Recovery equipment can be kept in efficient and safe working condition only if it is cleaned regularly, handled carefully and frequently inspected. Recovery personnel will then have full confidence in the ability of the equipment to stand up to its work.

b. Emphasis has been given to the safety factor used in the calculation of the safe working load of tackle. The safety of men can only be assured if the equipment is correctly used and properly maintained.

c. This chapter refers to the equipment described in Chapters 5 and 6. Care of recovery vehicles, is contained in the appropriate user and technical handbooks.

1402. FREQUENCY OF INSPECTIONS

Some items of recovery equipment are issued with a vehicle while others are included in the unit equipment tables. The unit inspection of recovery equipment should take place so as to coincide with the inspection of the recovery vehicles to which it belongs. All the recovery equipment should be laid out during this inspection.

1403. EXAMINATION AND TESTING

A large range of recovery equipment comes under the category of lifting tackle. No lifting tackle should be taken into use for the first time unless it has been tested and thoroughly examined. In the case of service equipment, provided visual examination shows the tackle to be in good condition, it can be assumed that new stocks accepted into the service have been correctly tested.

SECTION 2 - CARE OF CORDAGE

1404. HANDLING AND CARE OF CORDAGE

a. In the handling and care of cordage the important points to remember are as follows:

(1) Always examine cordage for wear and fraying before using it on a recovery job.

(2) Do not store cordage in a damp place.

(3) After use in mud, clean cordage by washing. Dry before stowing.

(4) Never pull a fibre rope over a sharp edge. A gun plank or skid correctly placed will prevent wear and possibly breakage.

(5) Adjust slings so that the splice does not bear on an edge or corner. Take up the load without snatch.

(6) Avoid dragging cordage through sand as it will penetrate the inner fibres and cut them by abrasion.

(7) Repair damaged or broken strands of cordage as quickly as possible.

(8) Use knots that can be readily untied and thus avoid having to cut a rope. The most suitable knots for recovery work are shown in Annex B.

(9) When cutting cordage always apply two whippings first, then cut between them.

(10) Store cordage in neat coils to prevent it becoming tangled.

1405. PROTECTION OF CORDAGE

a. Portions of a fibre rope likely to be subject to chafing or continuous wetting during use must be preserved or protected if a reasonable life is to be obtained. This applies in

particular to ropes containing a splice. Protection is afforded by the processes of worming, parcelling and serving the ropes as follows:

(1) Worming. The object of worming a rope is to fill up the space between the strands with spun yarn or small cordage and so render the surface smooth and round for parcelling and serving. The size of cordage selected as worming will naturally depend on the size of the rope to be wormed. The manner in which it is applied is depicted at A in Figure 58.

(2) Parcelling. Figure 58 also shows at B how parcelling is effected by applying a covering of hessian, canvas or other suitable material in strip form. The parcelling is laid with the lay of the rope, each turn overlapping the one that precedes it. The ends of the parcelling must cover the ends of the worming.

(3) Serving. Figure 59 shows how a binding of spun yarn has been applied at A by means of the serving mallet B. The underside of the mallet is so shaped as to ensure that it fits snugly on the rope to be served. Serving is always applied against the lay of the rope, the spun yarn being kept in tension by the turns taken round the handle of the serving mallet. As the mallet is rotated round the rope the serving is continuously fed under tension along the path indicated. The final result is an unbroken series of turns all laid closely together, securing the worming and parcelling in place. The end of the serving is completed by passing the spun yarn under the last two or three turns and pulling taut.

b. The strands at the end of a rope tend to unlay during use. This should be prevented by applying a whipping which, if carried out with skill, does not materially increase the diameter of a rope. It should still be free to enter sheaves of other tackle. The operation is carried out in four stages as shown in Figure 60.

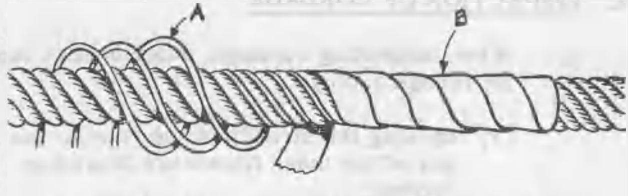


Figure 58 - Worming and parcelling cordage

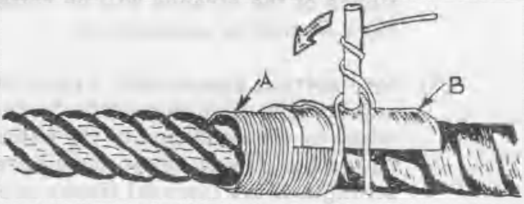


Figure 59 - Serving cordage

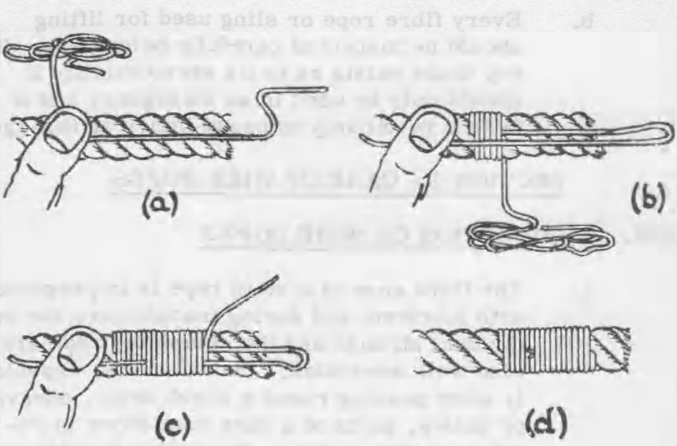


Figure 60 - Whipping cordage

1406. JOINING CORDAGE

A strong permanent joint in a rope can only be effected by splicing the ends together. This technique is employed also when inserting a thimble in the end of a rope to form an eye. The methods for splicing hemp rope are described in Annex C.

1407. INSPECTION OF CORDAGE

a. When inspecting cordage, deterioration may be recognized by:

(1) opening the strands of the rope to see if any of the inner fibres are frayed or broken;

(2) a mildewed appearance in rope which has been stored in a damp place; such rope will have a musty odour and the inner fibres of the strands will be rotted or dark stained in appearance;

(3) the external appearance - over-strained and bruised rope may often be recognized by the condition of the external fibres but it may retain considerable strength if the internal fibres are undamaged.

b. Every fibre rope or sling used for lifting should be inspected carefully before use. If any doubt exists as to its serviceability it should only be used in an emergency and if failure is unlikely to cause injury or damage.

SECTION 3 - CARE OF WIRE ROPES

1408. LUBRICATION OF WIRE ROPES

a. The fibre core of a steel rope is impregnated with lubricant and during manufacture the individual strands and the completed rope are also well lubricated. Under stress, especially when passing round a winch drum, sheave or pulley, parts of a wire rope move in relation to one another. To reduce friction and wear the rope must be kept clean and free

from rust and well lubricated with oil. When this special lubricant is not available engine oil may be applied with a stiff brush or by wiping the rope with oily waste.

b. After use in sea water, wire rope should be thoroughly washed in fresh water, dried and carefully lubricated.

1409. HANDLING OF WIRE ROPES

a. Care must be taken when handling wire rope to avoid twisting and untwisting and particularly kinking since the rope becomes permanently weakened at a kinked section and will eventually break.

b. When uncoiling a wire rope the formation of loops, which readily lead to kinks, must be avoided. If a loop occurs in a slack rope it must be carefully straightened out before a load is applied. A kink cannot be removed by pulling the rope but must be unwound in the opposite direction to that in which it was formed.

1410. WHIPPING AND CUTTING WIRE ROPES

a. The ends of wire rope must be whipped to prevent the strands from spreading. The number of whippings to be applied is equal to the number of inches in the circumference taken to the nearest inch, the space between the whippings being about two-thirds of the rope circumference. Annealed iron wire should be used for this purpose and wound evenly and tightly around the rope by hand until the whipping is of a length equal to about half the circumference of the rope. The ends should then be twisted together in a counter-clockwise direction, just sufficiently to take up the slack.

b. To prepare a wire rope for cutting, the number of whippings required is doubled and the cut is made between the middle two, each of the resulting ends then having the required number of whippings. Figure 61 shows the

manner in which whipping is applied prior to cutting a wire rope.

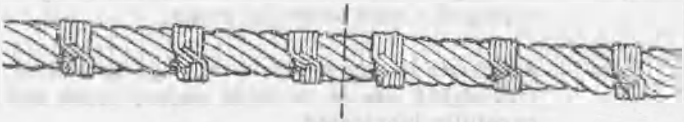


Figure 61 - Whipping wire rope

1411. USE OF CLIPS WITH WIRE ROPE

a. Clips of the U bolt type should be attached in the manner shown in Figure 62. It is important that the U bolt should bear against the running (or free) end and the base of the grip against the standing end, that is the end under load, since the base has considerably more gripping surface.

b. The number of grips to be used may be determined from the formula:

$$N = C + 1$$

Where N is the number of grips and C is the circumference of the rope in inches.

c. The spacing of the grips to ensure maximum holding power is determined simply as follows:

$$D = 2C$$

Where D is the distance in inches between grips and C is the circumference of the rope in inches.

d. Therefore in the case of a rope 2 3/8 inches in circumference, the number of grips would be 2 3/8 + 1 = 3 3/8, say 4. The grips in this case would be spaced 2 X 2 3/8 = 4 3/4 inches apart.

e. Knots are seldom used in wire ropes. In exceptional circumstances however, a rope may be attached to a pole, tree or similar object in the manner shown in Figure 63 which depicts a clove hitch with the running end

secured by means of a pair of U bolts.

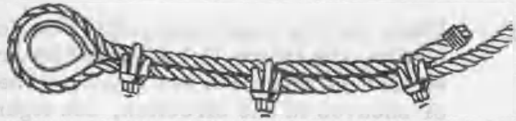


Figure 62 - U bolt clips

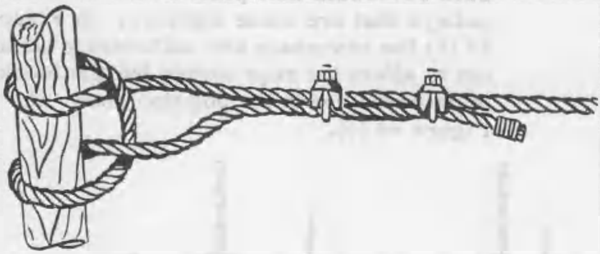


Figure 63 - Clove hitch secured by U bolt clip

1412. USE OF WIRE ROPES IN TACKLES AND ON WINCH DRUMS

a. Newly fitted rope should be worked several times under light load to enable the rope to adjust itself to working conditions.

b. Ropes should always be wound on or off a winch drum under tension. Coils wound loosely on to the drum will cause slip and snatch under load with the danger of the rope jumping off the winch drum or becoming jammed.

c. Rope must not be allowed to bear on sharp edges or rough surfaces. It will become deformed by the strands spreading.

d. The diameters of winch drums, pulleys and sheaves should not be less than those shown in Table 2 for commonly used ropes if distortion and overstressing is to be avoided. As a rough guide the diameter should not be less than five times the circumference of the rope.

e. The sheave or pulley grooves should fit the ropes. Binding on the sides will occur if the groove being used is too narrow or flattening of the rope will occur if the groove is too wide.

f. When reeving rope over pulleys or round blocks, the tackle layout should be arranged so that the rope is taken round all the pulleys or sheaves in one direction, see figure 64 (a). Reversing the direction of reeving has a damaging effect on the rope particularly when such reversals take place round sheaves or pulleys that are close together. In Figure 64 (b) the reversals are sufficiently far apart not to affect the rope unduly but the blocks must never reach the position shown in Figure 64 (c).

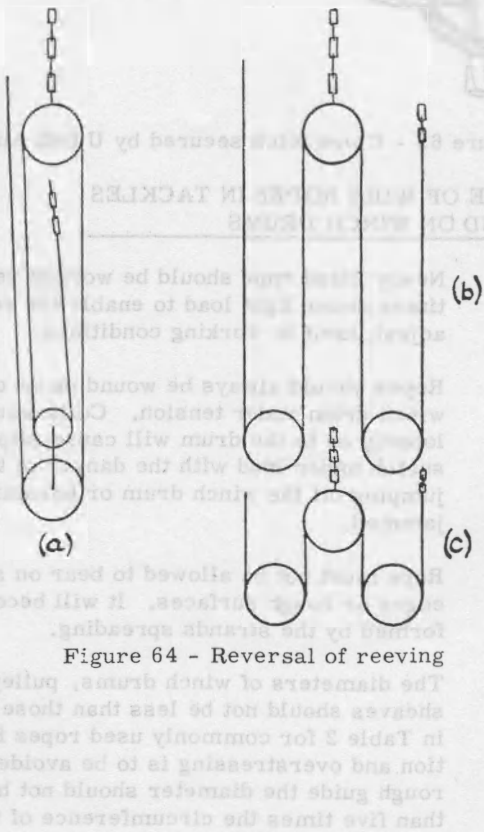


Figure 64 - Reversal of reeving

g. If a rope is wound on a winch drum wrongly in relation to the direction of its lay, lengthening of the lay or deformation due to local tightening of the strands will lead to unsatisfactory service. To determine the correct direction of winching, first check the lay of the rope as shown in Figure 65 and then, assuming that the first coil must be laid on the far end of a stationary drum, a rope with right hand lay must be wound in a clockwise direction and one with a left hand lay anti-clockwise, as in Figure 66.

1413. JOINING WIRE ROPES

The method of joining wire rope by splicing and the method of fitting a thimble in the end of a rope to form an eye are described in Annex D.

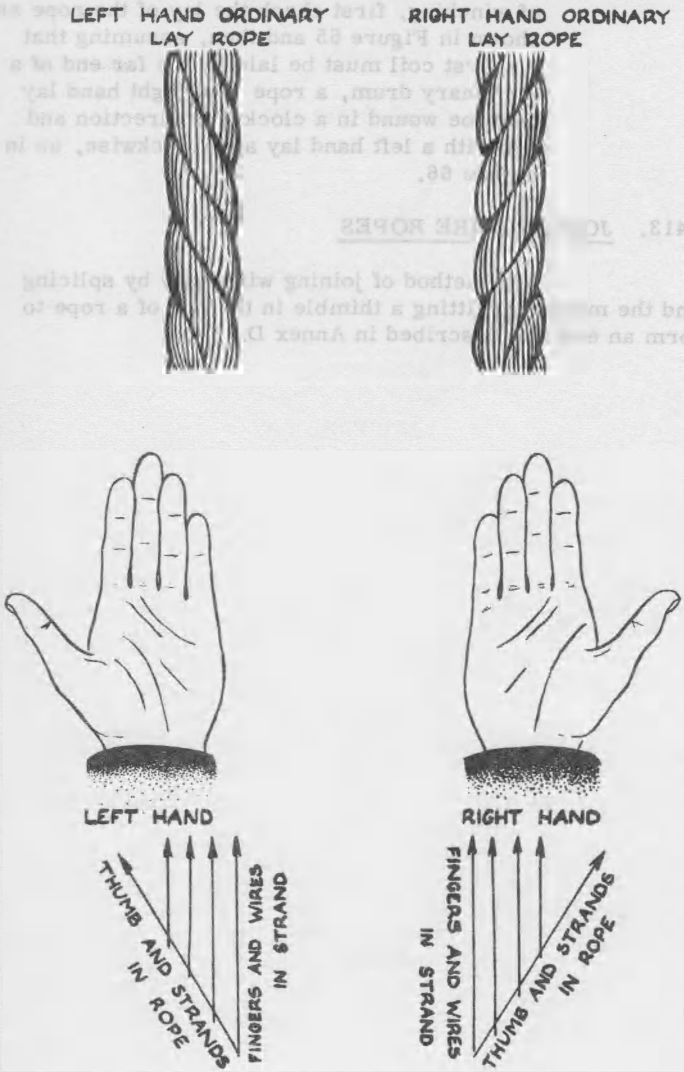
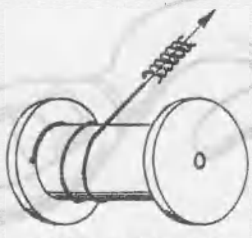


Figure 65 - Lay of rope



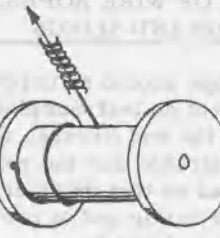


Figure 66 - Direction of rope on winch drum

1414. FITTING A NEW ROPE TO A WINCH DRUM

a. When a winch rope can be fitted directly to a drum no initial preparation of the rope is necessary other than whipping the end to facilitate entry through the slot and hole in the drum and thence under the securing clamp. In some cases it is necessary to attach a socket to the end of the winch rope prior to securing the latter in place on the winch drum. The method of doing this is described in Annex E.

b. To remove the twist induced in manufacture and coiling the rope must be wound on under a load of not less than 4 tons. The end must be attached to an anchorage by means of a swivel hook such as that shown in Figure 67.

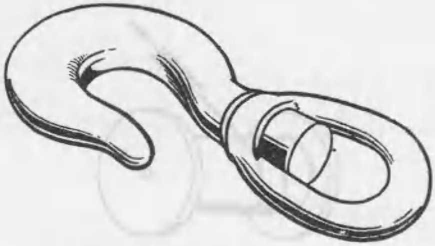


Figure 67 - Swivel hook

1415. INSPECTION OF WIRE ROPES, END FITTINGS AND SLINGS

a. Wire rope should be unreeved from the parent equipment so that complete inspection, including the end fittings, can be carried out. It is desirable that the rope be placed under light load so that deterioration may be detected more easily and to prevent the formation of kinks and snarls.

b. The points which require special attention are as follows:

(1) Ensure that a new rope is in accordance with its specification and, in the case of winch ropes, that the length is correct.

(2) Check that the rope is free from the effects of internal corrosion.

(3) Ascertain that the number of broken wires in the rope is not excessive. A wire rope should not be used if, in any length equal to eight diameters, the number of visible broken wires exceeds ten per cent of the total.

(4) Check that the amount of wear on the outer wires is not excessive and that the rope is kept clean and free from abrasives.

(5) See that the rope is free from malformation ie:

(a) kinking - due to incorrect handling;

(b) birdcaging caused by pulley or sheave grooves being too small;

(c) crushing - due to overloading while on the drum or to bad drum spooling;

(d) flattening - caused by pulleys or sheaves being seized up or their grooves being too large.

c. The points to watch for when inspecting wire rope apply equally to wire rope slings. In addition the end fittings on ropes and slings should be examined carefully for wear, cracks or deterioration at a splice.

SECTION 4 - CARE OF BLOCKS AND HYDRAULIC JACKS

1416. CARE OF TACKLE BLOCKS

a. Blocks must be kept clean and well lubricated. Sheaves should be examined for corrugations, unequal wear, flat surfaces or defective bearings as such conditions will cause the ropes to cut or jump the sheaves.

b. Snatch-blocks should be checked to see that the snatch will open and close freely. Metal blocks of this kind usually have in the sheave an oil reservoir fitted with a plug for lubricating the pin. This reservoir should be kept topped up with lubricant.

1417. CARE OF HYDRAULIC JACKS

a. It is essential that hydraulic jacks are kept in serviceable condition. They should be exercised under load at least once a week.

b. When topping up the reservoir with lubricant, care should be taken to release air through the bleed hole at the top of the cylinder.

ANNEX A

GLOSSARY OF TERMS USED IN CONNECTION WITH ROPES

Bend or hitch	A species of knot by means of which one rope is fastened to another or to an object such as a tree, ring, axle, etc.
Bight	A simple unknotted loop in a rope.
Core or heart	The central hemp portion of a steel wire rope. In flexible ropes the strands themselves may also have hearts of jute.
Fall line	The rope between a source of power, eg: a winch drum and the sheave of a suspended block or the pulley of a crane.
Fid	A wooden spike used for opening or lifting the strands of a rope.
Fixed block	A block which is attached to a fixed point in a tackle layout, eg: one which is attached to an earth anchor.
Frapping	Several turns of rope taken round a lashing in such a way as to render the lashing uniform and tight.
Guy	A rope (chain or rod) attached at one end to a fixed point and at the other to an object to be steadied.
Lashing	A binding of several turns of rope round two or more components to secure them.
Lay	The direction of twist in the manufacture of a rope.
Marlinspike	A steel spike used for opening or lifting the strands of a rope.

Mousing	Several turns of spun yarn or small cordage tied across the opening of a hook to prevent a rope (or another hook or ring) from slipping out.
Moving block	A block which is attached to a vehicle casualty or other load which has to be moved.
Parcelling	Covering rope with a binding of hessian, canvas or other suitable material.
Part	The rope, other than a fall line, running from a pulley or sheave.
Round turn	A simple unknotted loop in a rope, the rope being around an object.
Running end	The part of a rope which extends from an object made fast and which is not under load (see Standing end).
Seizing	A lashing of small cordage round two or more ropes in order to secure them. In the case of steel wire ropes, a lashing of annealed wire is used.
Serving	Binding parcelling with spun yarn or small cordage by means of a serving mallet.
Spun yarn	A number of fibres "laid up" into single yarn or yarns "laid up" from one to eighteen yarns.
Standing end	The part of a rope which extends from an object made fast and which is under load (see Running end).
Strand	A number of yarns or steel wire twisted, or formed, together.
Thimble	A grooved circular or heart-shaped lining for an eye formed in the end of a rope.

Unlay	To separate or untwist the strands of a rope.
Whipping	A binding applied to the end of a rope to prevent it unlaying.
Worming	Filling the space between strands of a rope with spun yarn or small cordage.

KNOTS AND LASHINGS

1. BENDS AND HITCHES

a. There is a wide variety of bends and hitches in general use. Those most applicable to recovery work are as follows:

(1) Half Hitch. Used for effecting a quick check on a light load, the running end of the rope being kept in the hand. Figure 1 shows how the hitch is made.

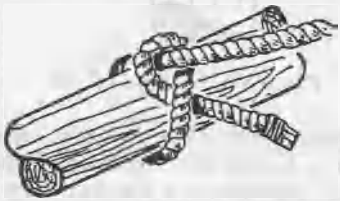


Figure 1 - Half hitch

(2) Two Half Hitches. This is a means of attachment of a rope to an object and is more secure than the simple half hitch. The running end may be seized as shown dotted in Figure 2.

Figure 2 - Two half hitches

(3) Clove Hitch. The clove hitch (Figure 3) is used for attaching a rope to a spar or similar article and for starting and finishing all lashings. It has the advantage of resisting any tendency to slip side ways.

Figure 3 - Clove hitch

(4) Sheet Bend. The principal use of this bend is to fasten two ropes of unequal size. It can also be used for securing one rope to the eye of another. Ropes of the same size may just as easily be jointed by means of this bend. Figures 4 (a), (b) and (c) show the formation of the single sheet bend and Figure 4 (d) the double sheet bend.

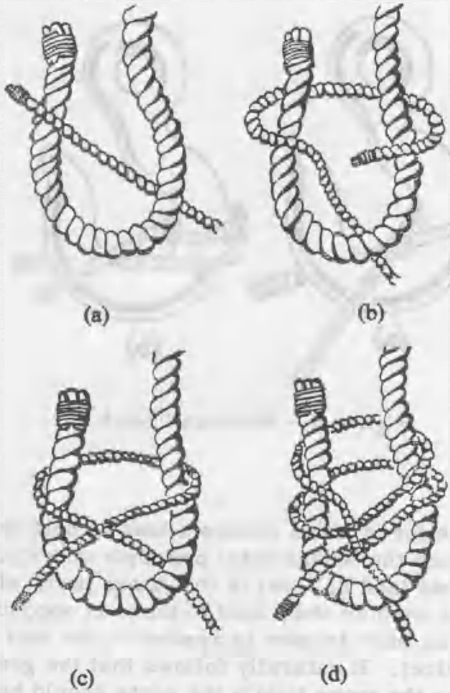


Figure 4 - Sheet bend

(5) Blackwall Hitch. Figure 5 (a) shows this hitch which is applicable only to a hook when used for vehicle loading. It is formed by taking a half hitch round the hook body so as to jam the running end under the standing end - the latter holding the former by friction so long as the tension is maintained on the standing end. The double blackwall hitch shown in Figure 5 (b) is a much more secure hitch and is made by taking one complete round turn after forming the single blackwall hitch. In both cases care must be taken to watch for slip if the rope is wet or greasy.

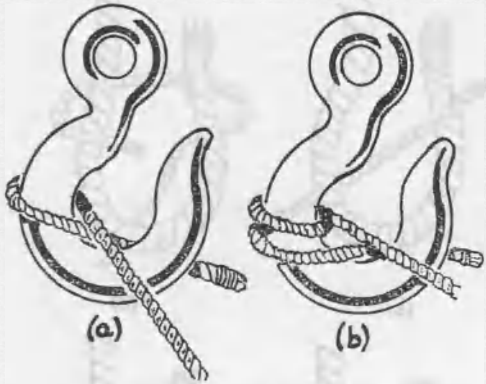


Figure 5 - Blackwall hitch

2. KNOTS

a. The force which causes a knot to hold is friction, hence the fundamental principle underlying all knots (and splices) is that those parts which touch one another shall tend to move in opposite directions when tension is applied to the knot (or splice). It naturally follows that the greater tension the more tightly the parts should be held or nipped together. A correctly tied knot will be easier to unfasten than one which is not.

b. Recognition of the correct knot to be used will assist in speedy and efficient work in recovery tasks. Knots must be tied correctly and mastery of this simple technique is essential to ensure safety and maintain confidence when dealing with heavy loads and difficult pulls. Knots most frequently used in recovery work are as follows:

(1) Overhand Knot. Figure 6 shows this very simple knot which is used to prevent the end of a rope from unlaying when time does not permit whipping. It has a low efficiency and tends to jam hard.

Figure 6 - Overhand knot

(2) Reef Knot. This knot, most frequently used, is quite often tied incorrectly. It should be used in tying ropes of equal size and to prevent jamming a piece of material, eg: a wood spike, is placed through its centre. Figure 7 (a) shows the correct form of the knot. The so-called granny is seen in Figure 7 (b) and the thief knot in Figure 7 (c). The thief knot appears to be exactly like the reef knot but the rope ends are diagonally opposite.

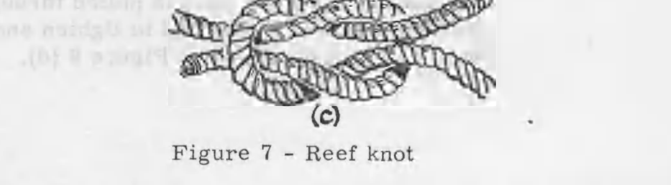


Figure 7 - Reef knot

(3) Ordinary or Standing Bowline. When it is required to form a loop that will not slip under load the bowline is the best knot. It may be untied fairly easily. Figures 8 (a), (b) and (c) show the stages of forming the bowline.

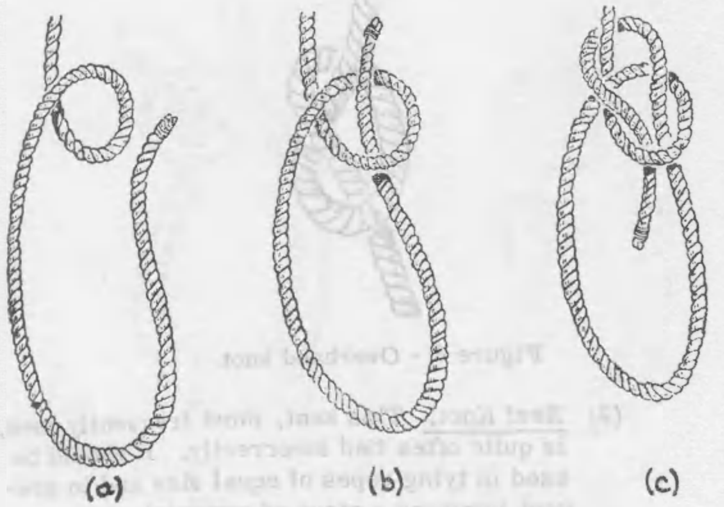


Figure 8 - Bowline

(4) Bowline on the Bight. This knot can be used to form a loop at any point and possesses all the features of the ordinary or standing bowline. If it is necessary to lower a man over a cliff or ravine during recovery operations this knot should be used as a seat sling. Figures 9 (a), (b) and (c) show the first stages in tying the bowline on the bight. With the main part of the rope grasped in the right hand and the loop A in the left hand, as seen in Figure 9 (c), the loop is then passed upward over the remainder of the knot with the left hand. The main part is pulled through the loop with the right hand to tighten and form the knot as shown in Figure 9 (d).

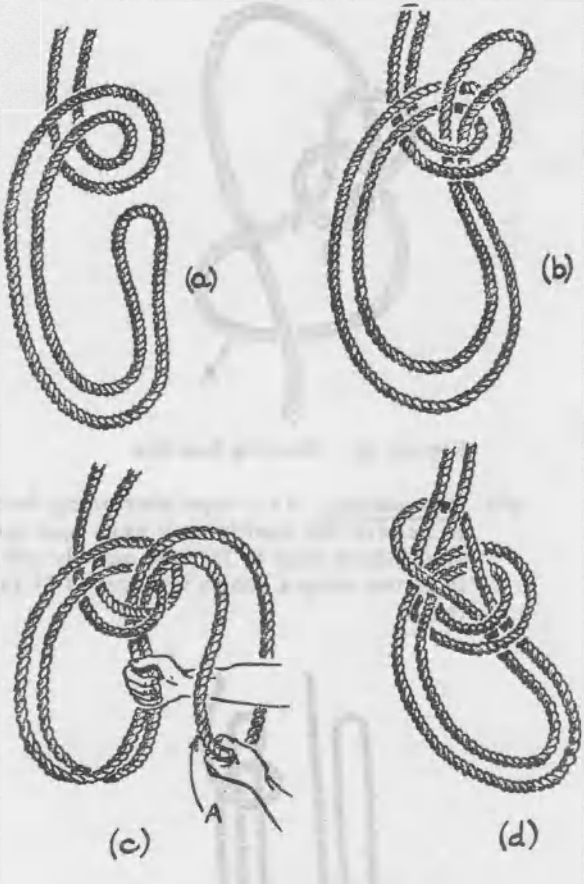
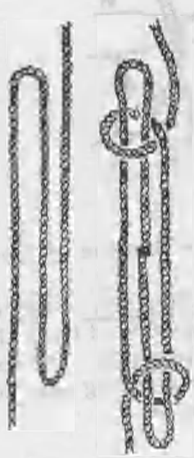


Figure 9 - Bowline on the bight

(5) Running Bowline. Figure 10 shows how this is simply derived from the ordinary or standing bowline. The loop A is formed round the standing part so as to produce a running noose.

Figure 10 - Running bowline

(6) Sheepshank. As a rope shortening device or to relieve the load from a weak spot the sheepshank may be formed quickly and simply in two stages shown in Figures 11 (a) and (b).



(a) *(b)*

Figure 11 - Sheepshank

(7) Catspaw. It is used for forming temporary loops in the bight of a rope when required for attachment to a hook. Figures 12 (a) and (b) show the formation of the catspaw.

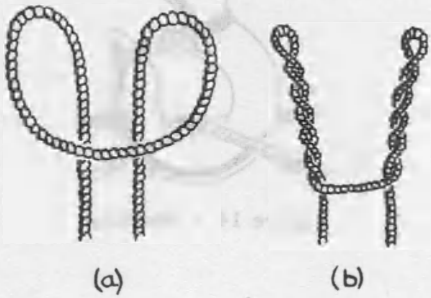


Figure 12 - Catspaw

3. FRAPPING

When two objects such as the spars depicted in Figure 13 (a) are lashed together, a further means of tightening may be used such as frapping as shown in Figure 13 (b).

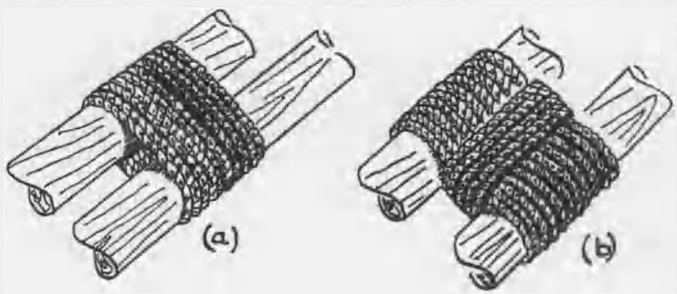


Figure 13 - Frapping

4. MOUSING A HOOK

To prevent slings, etc, from becoming detached from a hook, the opening of the hook may be moused with twine or other small cordage as shown in Figure 14.

Figure 14 - Mousing

SPLICING FIBRE ROPES

1. GENERAL

Rope splicing is essentially practical skill and is difficult to learn from text books alone. The methods described below need to be demonstrated by an instructor.

2. TYPES OF SPLICES

a. There are three forms of splicing with which recovery crews should be familiar. They are:

(1) a long splice used when the rope is required to pass smoothly and freely over the sheave in a block and it must retain its strength;

(2) a short splice used when the rope is not required to pass through a block and some reduction in strength is acceptable;

(3) an eye splice used when it is necessary to form an eye in the end of a rope.

3. THE LONG SPLICE

a. The long splice has the advantage of providing a joint in a rope approximately the same strength as the rope itself and does not appreciably increase the diameter of the rope. This is achieved mainly by tucking in the strands at different points along the joint.

b. The length of the long splice is determined by the size of the rope and the number of strands which comprise it. As a general guide the length should be about 12 to 16 times the circumference of the rope.

c. In forming a long splice the procedure is as follows:

(1) Apply a whipping to the point at which it is intended to unlay each rope. The strands will thus be prevented from running back any further.

(2) Unlay the two rope ends to a length approximately equal to six to eight times the circumference of the rope and whip each strand to prevent unlaying. Marry the two rope ends together as shown in Figure 1 (a) which depicts a three strand rope. The strands should be located alternately, A, B, and C to the left, D, E, and F to the right.

(3) The third operation is to unlay one strand only, for example A, to a length equal to half the overall length of the splice and to fill up the space thus left vacant with the strand D lying next but opposite to it until the free end of D is only a few inches long - see Figure 1 (b). Then turn the rope round and treat the next two strands in a similar manner, unlaying one and filling up the vacant space with the other. Two pairs of strands are thus interchanged and relaid as shown in Figure 1 (c) and the third pair are left at the point where the two ropes married. Each pair of ends may be tied to secure them for the subsequent operation (Figure 1 (d)), the long ends having been cut short and again whipped.

(4) The final operation consists of tucking in each of the six ends. Before doing so, it is essential to see that each pair of strands is lying as shown in Figure 1 (e). Now proceed to tuck each of these strands one under each strand as in Figure 1 (f), followed, if required, by one or two further tucks. The number of tucks should, however, be kept to a minimum since each tuck represents additional length to the portion of the rope enlarged by the splice. The strands of later tucks may be thinned down. When the splice is complete it should have all the ends cut off, be stretched and then rolled under foot so as to make it smooth and uniform in appearance.

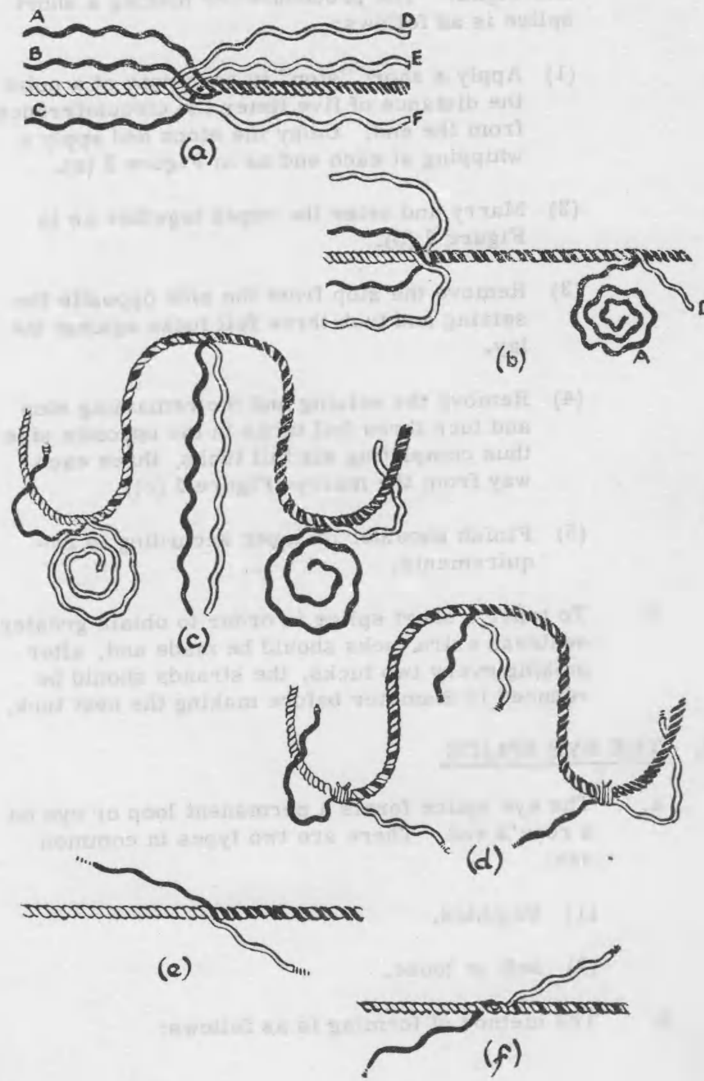


Figure 1 - Long splice, hemp rope

4. THE SHORT SPLICE

a. The short splice increases the size of the rope at the joint and the strength is reduced by about one-eighth. The procedure for making a short splice is as follows:

(1) Apply a short "stop" to each rope at a point the distance of five times the circumference from the end. Unlay the stops and apply a whipping at each end as in Figure 2 (a).

(2) Marry and seize the ropes together as in Figure 2 (b).

(3) Remove the stop from the side opposite the seizing and tuck three full tucks against the lay.

(4) Remove the seizing and the remaining stop and tuck three full tucks in the opposite side thus completing six full tucks, three each way from the marry (Figure 2 (c)).

(5) Finish shoulder or taper according to requirements.

b. To taper a short splice in order to obtain greater neatness extra tucks should be made and, after making every two tucks, the strands should be reduced in diameter before making the next tuck.

5. THE EYE SPLICE

a. The eye splice forms a permanent loop or eye on a rope's end. There are two types in common use:

(1) thimbled,

(2) soft or loose.

b. The method of forming is as follows:

(1) Apply a whipping or stop to the rope at a point the distance of five times the circumference from the end. The stop should be two diameters of the rope in length.

(2) When required, seize a thimble into the rope as in Figure 3 (a). Unlay the rope end and apply a whipping to each strand end.

(3) Tuck three full tucks against the lay following the start (Figure 3 (b)).

(4) To finish, an eye splice may be tapered or shouldered as in Figures 3 (c) and (d).

6. TO TAPER A SPLICE

After all tucks have been completed, each strand should be reduced by one-third and a full tuck completed with the remainder of the strand. Reduce again by halving and tuck once more thus completing two taper tucks. Trim off, leaving a one-quarter to one-half inch of the yarns protruding from the splice.

7. TO SHOULDER A SPLICE

After all tucks have been completed, each strand should be unlaid and halves from adjacent strands laid up and whipped (Figure 3 (c)).

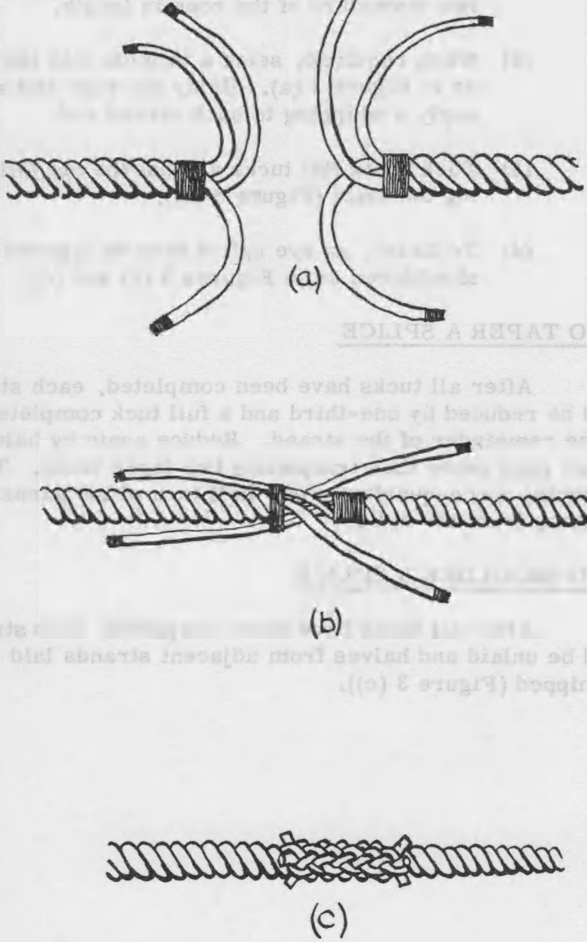


Figure 2 - Short splice, hemp rope

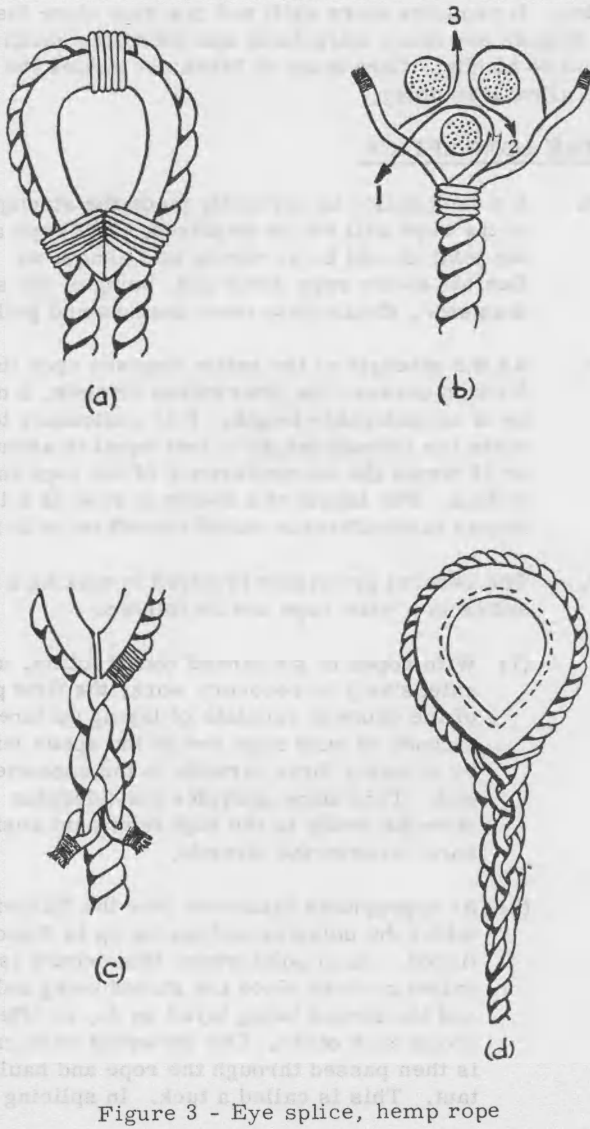


Figure 3 - Eye splice, hemp rope

ANNEX D

SPLICING WIRE ROPES

1. GENERAL

Wire rope splicing is similar to fibre rope splicing. It requires more skill and practice since the wire strands are more intractable and therefore much more difficult to handle. Care must be taken not to kink the wire nor to allow it to unlay.

2. THE LONG SPLICE

a. If a long splice is correctly made the strength of the rope will not be impaired. The rope at the joint should be as strong and almost as flexible as the rope itself and, being of the same diameter, should pass over sheaves and pulleys.

b. As the strength of the splice depends upon the friction between the interlocked strands, it must be of considerable length. It is customary to make the overall length in feet equal to about 16 or 18 times the circumference of the rope in inches. The length of a splice in rope of 3 1/2 inches circumference would therefore be 60 feet.

c. The general principles involved in making a long splice in a wire rope are as follows:

(1) With ropes of six strand construction, used extensively in recovery work, the first part of the process consists of laying up three strands of each rope end in the space left by unlaying three strands in the opposite end. This alone provides considerable strength owing to the high frictional resistance between the strands.

(2) At appropriate distances (see the following table) the unlaying and laying up is discontinued. Each point where this occurs is called a cross since the strand being unlayed and the strand being layed up do, in effect, cross each other. One strand at each cross is then passed through the rope and hauled taut. This is called a tuck. In splicing

wire rope, the tucks are made against the lay of the rope and great care must be taken to prevent kinks getting into either ropes or strands.

Size of rope		Length of strands unlayed (each side of marry)	Distance apart of crosses from marry		
Circumference	Diameter (approx)				
1 3/8"	1/2"	14'	11'9"	7'0"	2'3"
2"	5/8"	17'	14'3"	8'6"	2'9"
2 3/8"	3/4"	20'	16'9"	10'0"	3'3"
2 3/4"	7/8"	23 1/2'	19'6"	11'9"	4'3"
3 1/8"	1"	26 1/2'	22'3"	13'3"	4'3"
3 1/2"	1 1/8"	30'	25'0"	15'0"	5'0"
3 7/8"	1 1/4"	33'	27'6"	16'6"	5'6"

(3) The remaining parts of the strands are then buried in the rope and take the place of the hemp heart or core which is removed to make room for the strand.

(4) The point where the two rope ends are brought together is called the marry. If the ends are interlaced very closely it will be impossible, when the splice is completed, to see where the join occurred.

d. A steel wire rope of 3 1/2 inches circumference, having six strands each containing 37 wires, has been selected to describe in detail the method of making a long splice. This rope is typical of those used in recovery work.

e. From the table in paragraph 2 (c) (2) it will be seen that the total length of the splice will be 60 feet. In this case if the two lengths of rope to be spliced are, for example, 100 feet and 130 feet respectively, the finished rope will be:

$$100 + 130 - 60 = 170 \text{ feet.}$$

It follows, therefore, that it is useless to long splice two such ropes unless their total length is considerably more than 120 feet.

f. The detailed procedure is as follows:

(1) Measure off 30 feet from the end of each rope and from this point put on a stout serving of spun yarn. This is called a stop and prevents the strands from laying further back than required.

(2) Open up each rope sufficiently to apply a whipping of twine to each strand to prevent the individual wires from spreading.

(3) Unlay all the strands up to the serving and cut the hemp heart or core close to the stop.

(4) Referring to Figure 1 (a), bring the two ropes closely together, interlacing the strands so that a pair of adjacent strands of the right hand rope lie between the pairs of strands of the left hand rope and so on until all the strands are married. This operation may be facilitated by temporarily seizing or binding together the three pairs of strands of each rope a foot or so from the stop. The marry or join is shown at A.

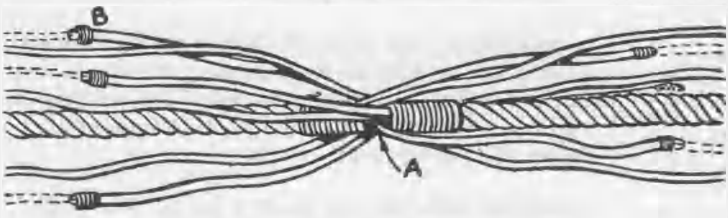


Figure 1 (a) - Long splice, wire rope

(5) Take any strand, put a whipping on it about a foot from the marry then cut off the strand with a hammer and chisel (or wire cutters) just beyond the whipping and discard the end cut off as at B Figure 1 (a). Leaving the

next strand intact, whip and cut the strand after it. Continue thus round the rope until there are three short and three long strands as shown in Figure 1 (b). Now proceed similarly with the opposite rope being careful to leave a long strand of one rope exactly opposite a short strand of the other rope.

(6) Now put a strong serving to the right of the marry, taking in all strands but one, as shown at C of Figure 1 (b). This will hold the ropes firmly together and will leave one short strand out ready for unlaying. The rope should then be triced up or supported in such a manner as to bring it approximately breast high for the subsequent operations. One method is to hang the rope from suitable overhead supports (such as the roof trusses of a building) or locate it on trestles placed at an appropriate distance apart.

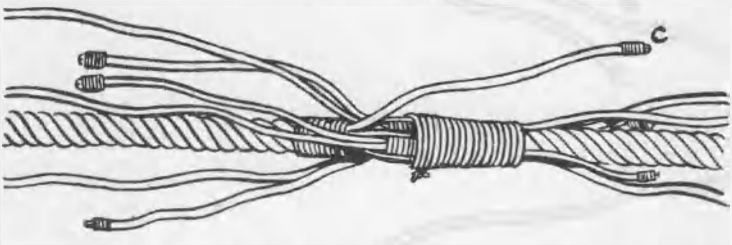


Figure 1 (b)

(7) Cut off the serving or stop on the left hand rope and gradually unlay strand C 25 feet to the left (see Figure 1 (c) and note table of lengths for unlaying in para 2 (c) (2)). Follow this up by laying the opposite strand D carefully and exactly in place of strand C. When 25 feet of strand D are layed up, put a serving at the point where the strands cross. There will now be 25 feet of strand D laid in the rope and some five feet of it left over which will be buried in the rope later. The strand C, which is being unlayed, may be cut off from time to time if it becomes awkward (whipping the end before, or immediately

after cutting) until five feet of it are left free or burying later in the rope see Figure 1 (d).

(8) To lay the corresponding 25 feet of strand from the left-hand rope in the right-hand rope, put a serving over the marry just to its left, leaving out one short strand of the right-hand rope (after removing the right-hand serving) and proceed as before.

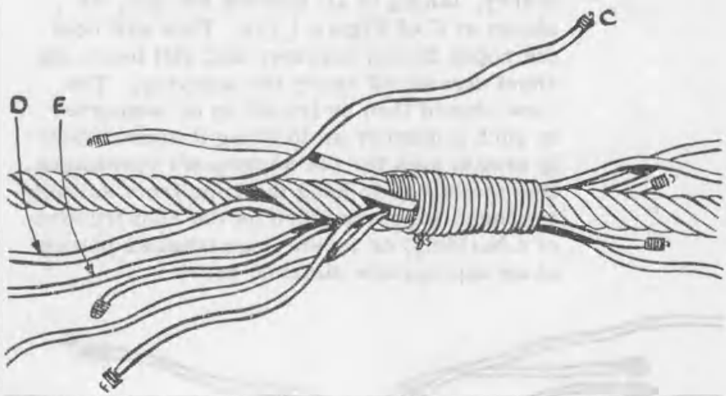


Figure 1 (c)

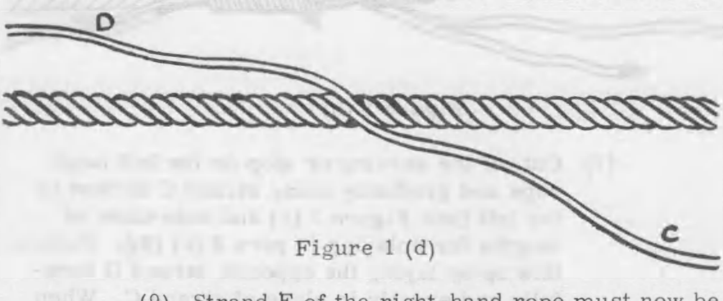


Figure 1 (d)

(9) Strand E of the right-hand rope must now be laid in the left-hand rope to a distance of 15 feet from the marry following the same procedure.

(10) The second long strand of the left-hand rope is now laid up in the right-hand rope to a distance of 15 feet leaving free, as before,

five feet of the unlaid strand and five feet of the laid-up strand.

(11) The last strands are similarly dealt with except that the distance from the marry is only five feet as shown in the table. A continuous rope has now been formed and there are six evenly spaced crossings, as depicted in Figure 1 (e), ten feet apart, from which 12 five-feet lengths emerge. These have now to be tucked and buried.

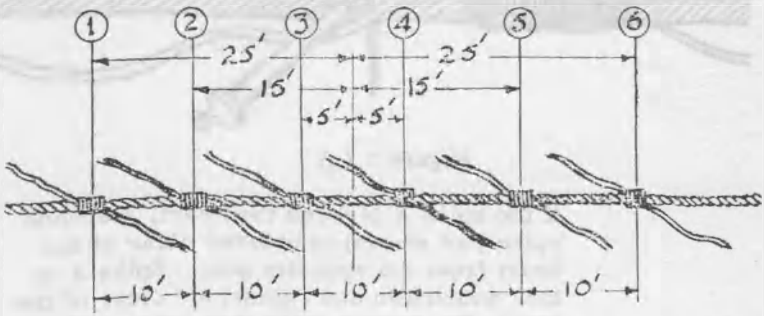


Figure 1 (e)

(12) Beginning at any one of the crossings, for example, No 1 at the left-hand end of the splice, the first action is to fix the laid-up end in position so that the rope can be manipulated without opening it any more than is desired. Figure 1 (f) shows the method of doing this. A strong serving of yarn A is placed over the rope to the left of the cross, the left-hand strand B then being placed over the serving and seized to the rope with a second serving of yarn C.

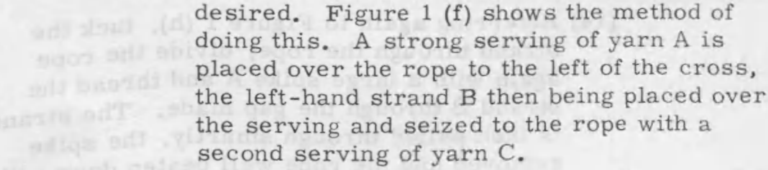


Figure 1 (f)

(13) The next operation is to cut out the hemp core or heart which must be removed to leave room for the strand of wire which is to take its place. Take a small marline-spike and drive it through the rope at the cross, ie under three strands and to one side of the heart, as at A in Figure 1 (g).

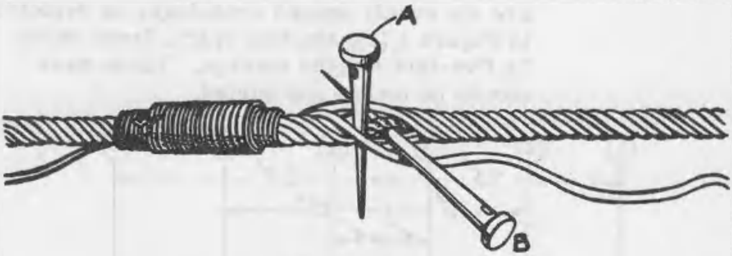


Figure 1 (g)

If the spike A pierces the heart, a second spike (not shown) is entered clear of the heart from the opposite side. Spike A is then withdrawn and reinserted clear of the heart, the second spike then being with-drawn. A similar spike B is next used to raise the heart, as shown in Figure 1 (g), sufficiently to cut it with a penknife. When the heart is cut, each end is pulled out an inch or so as seen in Figure 1 (h) and the spikes A and B are then withdrawn.

(14) Referring again to Figure 1 (h), tuck the strand through the rope, divide the rope again with a large spike A and thread the strand B through the gap made. The strand is then pulled through smartly, the spike removed and the rope well beaten down with a mallet. It will then appear as in Figure 1 (i). Care must be taken not to withdraw the marline-spike until the tuck is made and the slack of the strand has been drawn through.

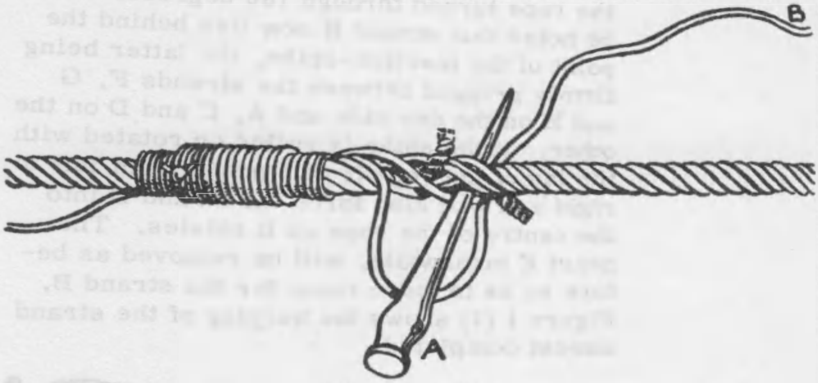


Figure 1 (h)

(15) The strand B in Figure 1 (i) is now ready to be buried but before doing so it must be served with yarn or twine (see Figure 1 (j)) to bring it up to the diameter of the heart. If suitable tape is available the strand may be parcelled as this will be equally effective and will save a considerable amount of time and labour.

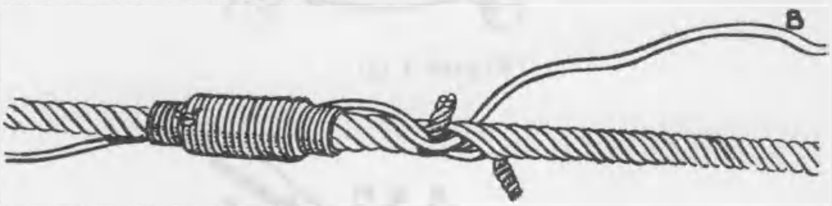


Figure 1 (i)

(16) To bury the strand the large spike is again thrust through the rope, as shown in Figure 1 (j), under the three strands A, C and D and also under the strand B which is to be buried. *It is then slewed in the direction of the arrow ready for the subsequent rolling operation. In order that the essential features of this operation may be appreciated, the rope must be viewed from the other side. This is indicated in Figure 1 (k) which shows*

the rope turned through 180 degrees. It will be noted that strand B now lies behind the point of the marline-spike, the latter being firmly gripped between the strands F, G and H on the one side and A, C and D on the other. If the spike is rolled or rotated with the lay of the rope it will travel from left to right and will also force the strand B into the centre of the rope as it rotates. The heart E meanwhile, will be removed as before so as to leave room for the strand B. Figure 1 (1) shows the burying of the strand almost completed.

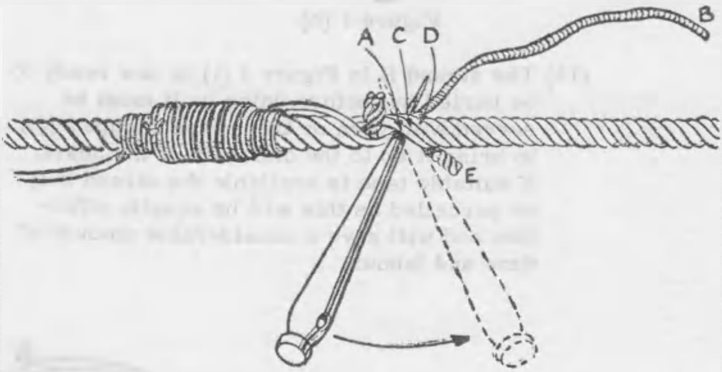


Figure 1 (j)

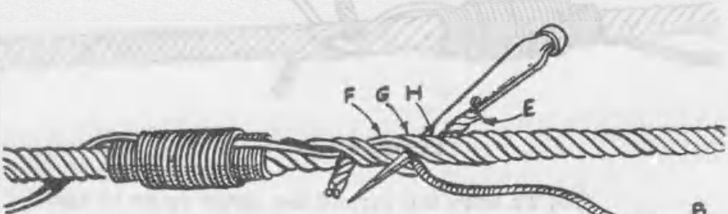


Figure 1 (k)

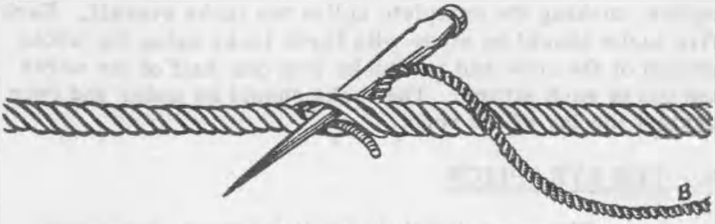


Figure 1 (l)

(17) When the strand B has been buried, the serving on the left-hand side of the cross is cut off and another serving is applied on the right-hand side of the cross. The splicer then passes to the other side of the rope and again drives the marline-spike through the centre, separating the strands and enabling the heart to be extracted while the strand is being buried by the rotation of the marline-spike as before.

(18) Care must be taken to see that the centre of the rope is completely filled with the steel strands, that no spaces are left between the ends and that at each end of the splice the strand actually meets the heart. At intermediate points the ends of the steel strands must butt closely together.

(19) When all the strands have been tucked and buried, the rope is placed on the floor and beaten into complete regularity with the mallet.

(20) It may be thought that there is an excessive number of servings and cuttings throughout this operation but although these precautions may seem somewhat tedious they are well worthwhile in the long run and will materially assist in producing a thoroughly sound splice.

3. THE SHORT SPLICE

The short splice in wire rope is carried out in a manner similar to that described in Annex C for fibre rope. The ends should be spliced, each to each with a five tuck

splice, making the complete splice ten tucks overall. Each five tucks should be made with three tucks using the whole strand of the rope and two tucks with one-half of the wires cut out of each strand. The tucks should be under and over against the lay of the rope.

4. THE EYE SPLICE

a. The eye splice is made in a manner somewhat similar to that described in Annex C in connection with hemp ropes. The length of the splice is necessarily limited and its strength is therefore due to the number of tucks employed. The rope is, in fact, plaited upon itself and when carefully made the strength of the splice will not be less than 90 per cent of that of the main portion of the rope.

b. To determine the length of rope required to make an eye splice allow one foot of rope for each inch of circumference. A rope of three inches circumference, for instance, should be unlayed for a distance of 36 inches to provide strands of sufficient length to make a satisfactory splice.

c. There is an appropriate size of thimble for each size of rope in common use and care should be taken that a suitable thimble is employed. The following table which refers to Figure 2 may be taken as a guide but all thimbles may not conform exactly to the dimensions given.

Size of rope		Dimensions					
Circumference	Diameter (approx)	A	B	C	D	E	F *(min)*
$1\frac{3}{8}''$	$\frac{1}{2}''$	$1\frac{1}{8}''$	$2\frac{1}{8}''$	$\frac{11}{16}''$	$1\frac{5}{8}''$	$2\frac{7}{8}''$	$\frac{1}{2}''$
$2''$	$\frac{5}{8}''$	$1\frac{5}{8}''$	$2\frac{15}{16}''$	$\frac{7}{8}''$	$2\frac{5}{16}''$	$3\frac{7}{8}''$	$\frac{5}{8}''$
$2\frac{3}{8}''$	$\frac{3}{4}''$	$1\frac{3}{4}''$	$3\frac{1}{8}''$	$1''$	$2\frac{5}{8}''$	$4\frac{1}{4}''$	$\frac{3}{4}''$
$2\frac{3}{4}''$	$\frac{7}{8}''$	$2\frac{1}{4}''$	$4''$	$1\frac{1}{4}''$	$3\frac{1}{4}''$	$5\frac{1}{4}''$	$\frac{7}{8}''$
$3\frac{1}{8}''$	$1''$	$2\frac{3}{4}''$	$4\frac{11}{16}''$	$1\frac{3}{8}''$	$4\frac{1}{4}''$	$8\frac{3}{8}''$	$1\frac{1}{16}''$
$3\frac{1}{2}''$	$1\frac{1}{8}''$	$3''$	$5\frac{1}{4}''$	$1\frac{1}{2}''$	$4\frac{3}{8}''$	$7''$	$1\frac{1}{8}''$
$3\frac{7}{8}''$	$1\frac{1}{4}''$	$3\frac{3}{4}''$	$6''$	$1\frac{5}{8}''$	$5\frac{1}{4}''$	$7\frac{3}{4}''$	$1\frac{5}{16}''$

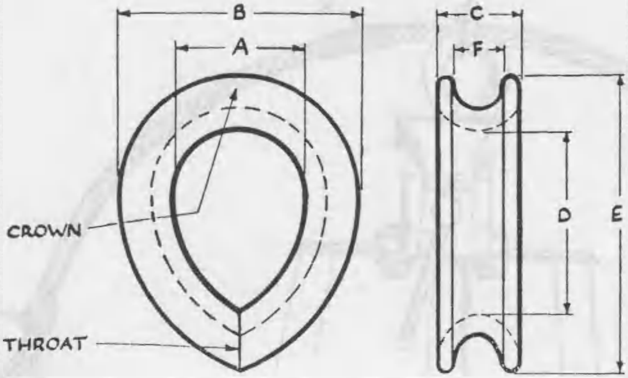


Figure 2 - Thimble

d. For the purpose of describing the operation it will be assumed that the requirement is to make a thimble eye splice at the end of a steel wire rope two inches in circumference having six strands each consisting of 37 wires.

e. When making an eye splice in wire rope (particularly in one of large size), hand up the rope in such a position that the part to be spliced will be at a convenient height for the operator.

f. The detailed operations are as follows:

(1) As the rope is two inches in circumference, measure off two feet from the end and, beginning at this point, put on a serving of spun

yarn about two inches long, serving (as always) against the lay (see X of Figure 3 (a)).

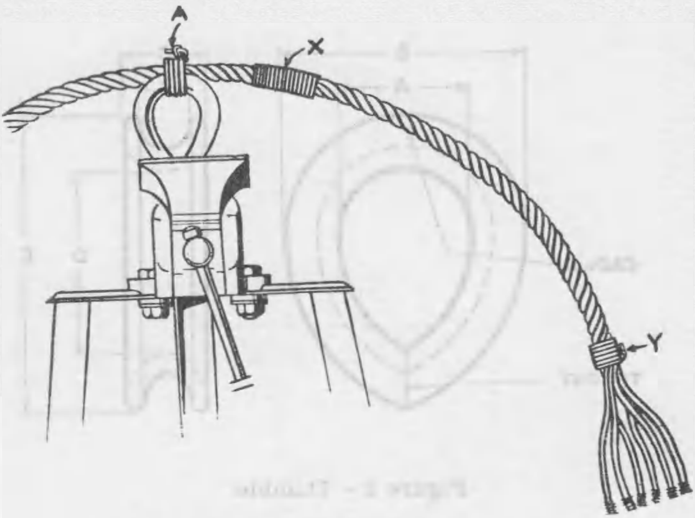


Figure 3 (a) - Eye splice, wire rope

(2) Next, put a light serving Y about eight inches from the end, unlay the rope and whip the end of each strand to prevent the wires from spreading.

(3) The rope must now be seized firmly to the crown or top of the thimble as shown in Figure 3 (a). Place the beginning of the two-inch serving in the grooves at the base or throat of the thimble and lay the rope round the thimble. Seize rope and thimble at the crown. This should be done in a vice as shown in Figure 3 (a).

(4) The next step is to bed the rope securely in the score of the thimble. Position the rope in the vice as depicted in Figure 3 (b) taking care to cover the jaws with cotton waste or sacking so as to protect the strands. Now manipulate both vice and rope so as to make the latter follow the groove of the thimble closely and with a minimum of play. Two

more seizings should now be applied at B and C, just above the throat of the thimble, one on each side. In the case of the larger ropes it may be advisable to put on two intermediate seizings between crown and throat. If the vice work is carried out slowly and carefully the three seizings will usually suffice to hold the rope firmly in position (see Figure 3 (b)).

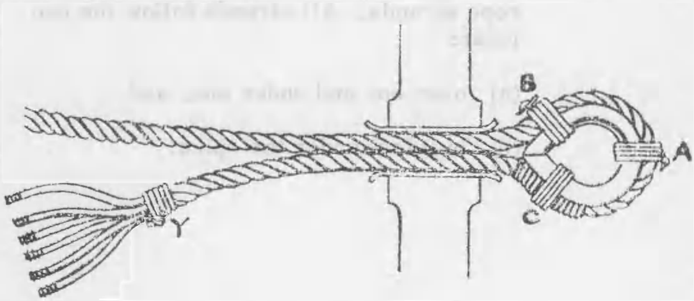


Figure 3 (b)

(5) The rope should now be triced up in a vertical position, thimble in the vice. Remove the temporary stop Y, Figure 3 (b) and unlay the tail strands as far as the throat stop. This will expose the fibre heart which should be cut out of the rope at a point close to the throat stop. The tail strands are now arranged three each side of the standing part as in Figure 3 (c) and are numbered as in Figure 3 (d). The interstices of the standing part are lettered in the figure.

(6) The rope is now ready for splicing. The splice should consist of five tucks against the lay, three full tucks with a whole strand of the rope and two tucks with one-half of the wires cut out of each strand. The sequence of the first tuck is shown in Figure 3 (e); Figure 3 (f) shows the position after the first tuck of strand No 1. Figure 3 (g) shows the position after the first tuck of strands Nos 1, 2 and 3. On completion of

the first tuck, the splice should be beaten up and a keep serving applied over it.

(7) The second tuck is made by taking each strand in order from 1 to 6 carrying it over the strand next to the one under which it was first tucked, under the following strand and out. In this and all succeeding tucks, strand 6 is dealt with in the same manner as all the other strands and is not tucked under two rope strands. All strands follow the two rules:

(a) over one and under one, and

(b) pull taut under the spike.

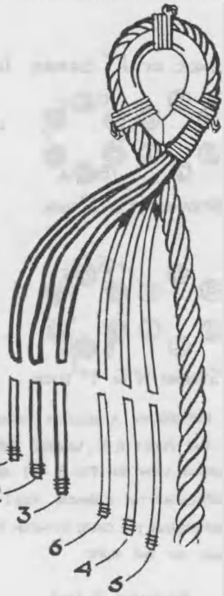


Figure 3 (c)

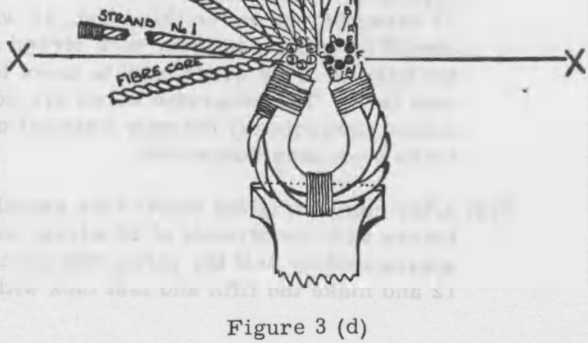
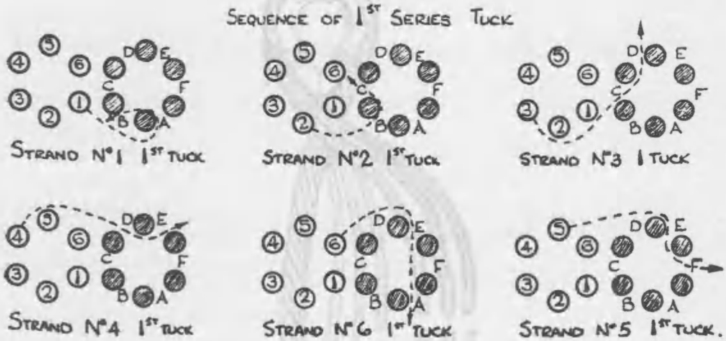


Figure 3 (d)



NOTE 1 THE ABOVE DIAGRAMS REPRESENT A SECTION THROUGH THE MAIN PART AND TAIL OF THE ROPE AT THE POINT X-X, WHERE THE SPLICE STARTS (SEE THE PARTLY EXPLODED VIEW IN FIG.3 (d) ABOVE)

NOTE 2 THE NUMBERS 1 TO 6 REPRESENT THE STRANDS NOS 1 TO 6 OF THE TAIL OF THE ROPE THE LETTERS A TO F REPRESENT THE GAPS BETWEEN THE STRANDS OF THE MAIN PART OF THE ROPE

Figure 3 (e)

(8) When the second tuck is completed put on a serving as before and proceed again, exactly as in sub-paragraph (7) above, to complete the third tuck.

(9) There are five tucks in all and, although the last two are made in exactly the same manner, it is necessary to taper the splice by gradually reducing the number of wires in the strands. Before making the fourth tuck therefore, one-third of the wires is separated from each strand. As there are 37 wires per strand in this rope, 12 wires should be separated from each strand and the balance of 25 wires used to make the next tuck. The separated wires are not removed immediately but only when all of the tucks have been completed.

(10) After completing the fourth tuck exactly as before with the strands of 25 wires, separate approximately half the wires remaining, ie 12 and make the fifth and last tuck with the

balance 13. Now cut off the temporary servings, beat the splice into regular shape with the mallet or splicing hammer and finally cut (or break) off the untucked wires referred to above. The better method is not to cut the wires but to take each one and bend it back and forth until it breaks as this produces a little hook which is preferable to the sharp end produced by cutting. With a highly flexible rope of many wires, however, this is a labourious process and may not be worthwhile, particularly if time is of importance. On the conclusion of this operation, the splice will present the general appearance in Figure 3 (h).

NOTE. Strands 4, 5 and 6 are not shown in Figures 3 (f) and (g).

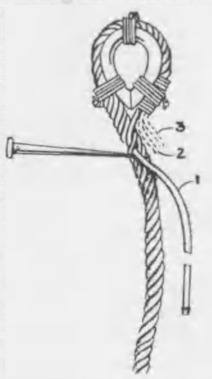


Figure 3 (f)

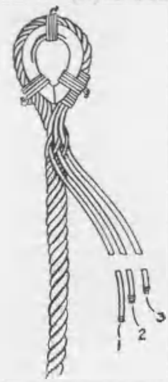


Figure 3 (g).

(11) After cutting off the seizings, the splice should be parcelled as shown in Figure 3 (i). The parcelling starts from the throat of the thimble while the serving starts as at A working up the throat. Bear in mind the rule contained in the couplet:

Worm and parcel with the lay
But turn and serve the other way.

Figure 3 (h)

Figure 3 (i)

ANNEX E

FITTING A SOCKET TO A WIRE ROPE

1. The following method is used for fitting a socket of the kind shown in Figure 1 to a wire rope such as a winch rope:

a. Securely whip the rope at a distance from its end equal to the length of the socket and grip it in a vice as shown in Figure 1 (a). Clean the wires and cut out the hemp core. Then position the socket and knock it down into place as shown.

b. Next separate the wires as shown in Figure 1 (b) using flat nosed tongs or pliers so that all the wires are evenly spread to fill the socket. Do not crimp the wires over the edge of the socket.

c. The junction of the rope and socket should be tightly served with asbestos yarn to prevent the escape of the molten metal. The socket should now be heated gradually and evenly to a temperature of 100 degrees centigrade (212 degrees fahrenheit). Immediately before pouring the metal, sprinkle the wires with powder resin.

d. Pour in molten metal as shown in Figure 1 (d). This should be heated to approximately 350 degrees centigrade and poured to a level slightly above the top of the socket to allow for shrinkage of the metal on cooling. A rough and ready method of gauging the temperature of the molten metal is to immerse one end of a piece of soft dry white wood such as a matchstick in the molten metal for a few seconds. The temperature will be roughly correct when it is such that it will only slightly discolour or char the wood. If the wood stains rapidly with smoke or flame, the metal is too hot and must be allowed to cool to the correct temperature before pouring.

e. Trim the end of the metal and wires to a neat finish.

2. To fit an adaptor assembly such as shown in Plate 8 to a wire rope:

a. Thread the rope through the bush, passing the bush well along the rope.

b. Measure from the end of the rope a length equal to the length of the tail plus one-half inch and mark the rope (Figure 2 (a)).

c. With the aid of two marline-spikes expose the heart of the rope and cut it level with the chalk mark (Figures 2 (b) and (c)). Lift out the portion to be removed and with the aid of a spike roll the heart out of the rope (Figure 2 (d)).

d. Pass the cone and tail unit into the rope as at Figure 2 (e) and roll the tail into the rope by rotating the spike for a length of approximately nine inches. Tap the cone into position ensuring that the tail is level with the chalk mark. Pass the tail fully home.

e. Unlay the rope's end and close it around the cone (Figure 2 (f)).

f. Fit the adaptor to the bush and tighten up the bolts (Figure 2 (g)).

g. Ensure the adaptor is free to rotate on the bush. Apply a whipping of single strand annealed wire immediately behind the bush.

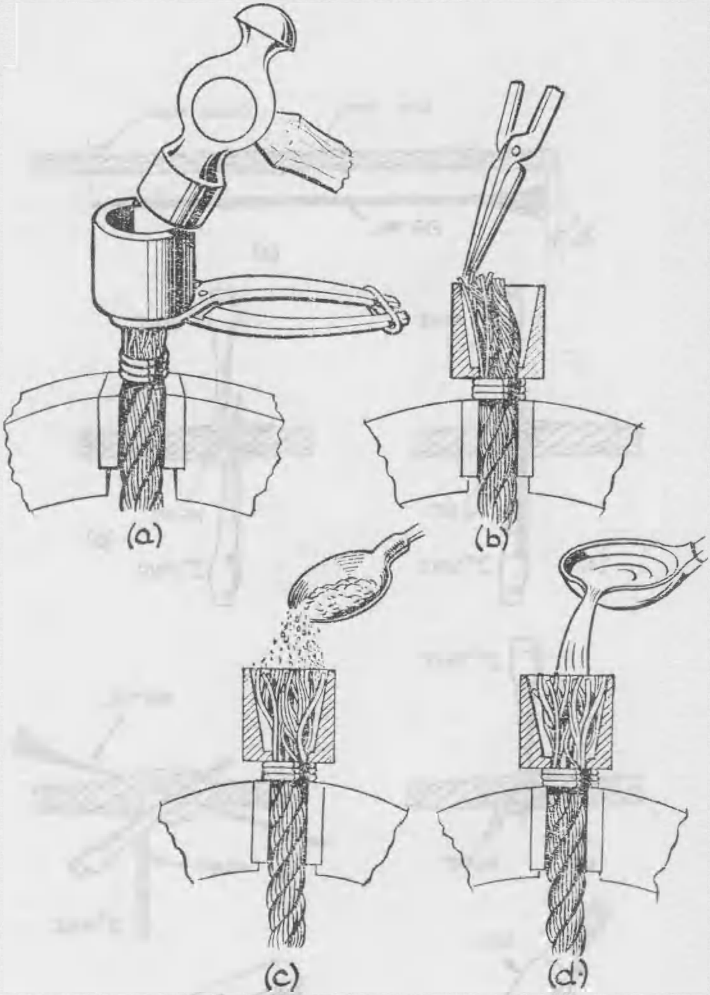


Figure 1 - Fitting socket to wire rope

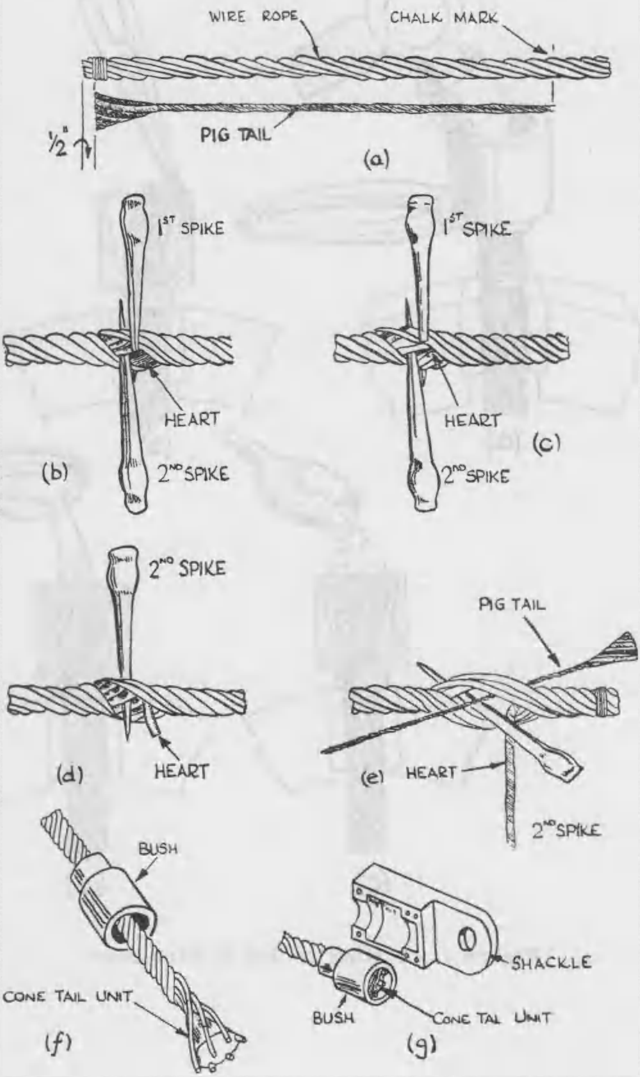


Figure 2 - Fitting adaptor assembly to wire rope

RECOVERY SIGNALS

1. GENERAL

a. The method of transmitting orders and instructions during a recovery operation depends on circumstances. For many purposes verbal orders and instructions are clearly the best way but for the control of winching and vehicle movements a system of signals is frequently required. The following paragraphs describe the signals in normal use.

b. It is essential that SIGNALS TO A DRIVER OR OPERATOR BE INITIATED BY ONE PERSON ONLY, normally the crew commander or a nominated officer or NCO when more than one vehicle or winch is being used. Before signalling for a load to be applied, the individual giving the signal must make sure that everyone is standing clear otherwise failure of equipment or the parting of a rope is likely to cause serious injury to anyone within range.

2. HAND SIGNALS

a. This is the usual system of control by day. The signals have been standardized throughout the army and should not be varied.

b. When manoeuvring a vehicle or controlling a winch the person initiating the signals will sometimes be able to stand in full view of the driver or operator and transmit the signals direct. At other times, particularly when directing winching operations or reversing a transporter, he may have to stand beside the equipment casualty or behind the recovery vehicle. His signals will then be relayed by another member of the crew positioned in front of and in full view of the vehicle driver or winch operator.

c. The recognized hand signals illustrated in Figure 1 are:

(1) Advance. Beckon the driver to advance by extending the right arm to the front, bringing the hand upwards and towards the face in a circular motion.

(2) Reverse. Extend both arms towards the front and in line with the shoulders and raise the forearms with the palms of the hands toward the vehicle. Move the forearms backwards and forwards as long as the reverse movement is required.

(3) Halt. Raise both arms with the palms open towards the driver.

(4) Change Direction. (Whether advancing or reversing) Extend one arm with fist clenched in line with shoulder in the direction in which the vehicle is to move. In the case of wheeled or semi-tracked vehicles, the driver will continue to turn his steering wheel as long as the arm is extended. When the required turn has been completed, drop the arm to the side. The driver will then continue reversing (or advancing) until he receives a further signal. In the case of tracked vehicles, the driver will continue to maintain the pressure on the steering lever as long as the arm is extended. When the required turn has been completed, drop the arm to the side. The driver will then continue in the direction in which it is aligned.

(5) Winch In. Raise the right arm above the head with the palm facing inwards and slowly describe a circular path with the hand. Winching (or hauling manually on a rope) will continue as long as the signal is being given.

(6) Pay Out. Extend the right arm in line with the shoulder with the palm facing downwards. Raise and lower the arm from the shoulder through an angle of approximately 30 degrees. Paying out the winch rope (or manually hauled rope) will continue as long as the signal is being given.

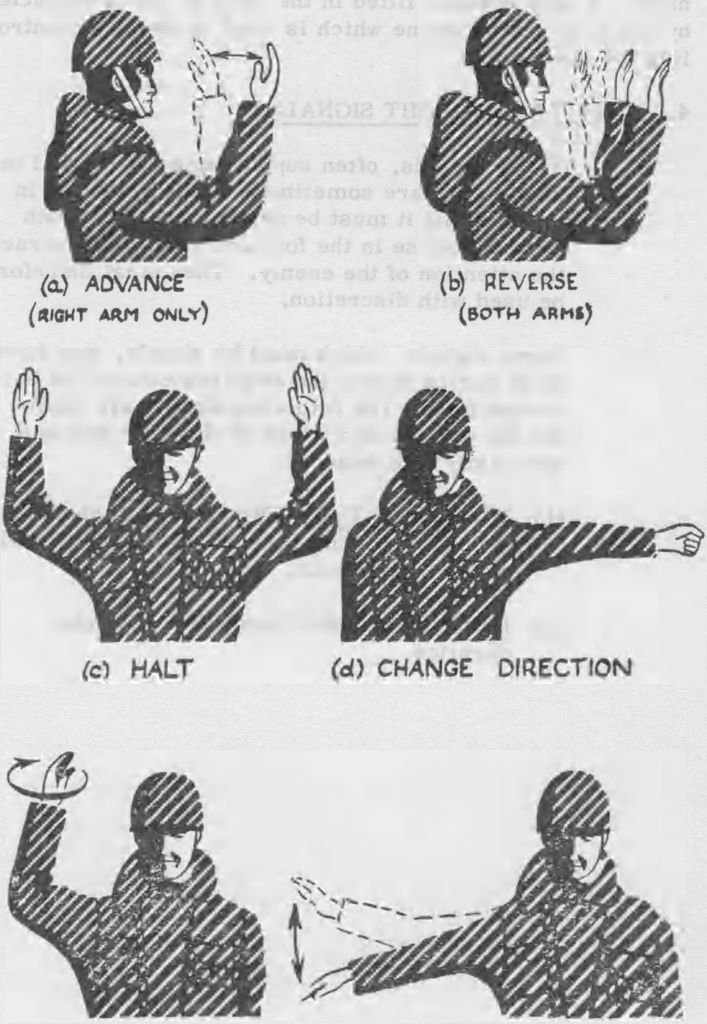


Figure 1 - Hand signals

3. INTERCOMMUNICATION BY TELEPHONE

For recovery vehicles that are suitably equipped this is the most efficient system of control, particularly at night. A loud speaker fitted in the vehicle cab is connected by cable to a microphone which is used by the NCO controlling the operation.

4. LAMP/FLASHLIGHT SIGNALS

a. These signals, often supplemented by verbal instructions, are sometimes used for control in the dark but it must be remembered that both light and noise in the forward areas may attract the attention of the enemy. They must therefore be used with discretion.

b. Lamp signals, which must be simple, may have to be varied to suit the requirements of the particular task. The following signals are useful for the control of a winch or drawbar pull and are easily remembered:

(1) Winch In or Tow. Two flashes of about five seconds duration, separated by an interval of the same length.

(2) Halt. One flash of about five seconds duration.

ANNEX G

SHORTENING TRACK OF A CENTURION TANK WITH A DAMAGED SUSPENSION

1. MOBILITY

a. A Centurion tank with a damaged suspension can be made mobile in two ways:

(1) by complete removal of the track so that it can be towed on its road wheels;

(2) by shortening the track to bypass defective suspension assemblies.

b. It must be appreciated before a decision is made that:

(1) after complete removal of a track the casualty cannot proceed under its own power;

(2) a track should not be removed completely if there is a danger of sinking in soft ground;

(3) shortening a track will not incur the danger of sinking and in certain circumstances, as explained in paragraph 2 (a) below, the casualty can then proceed under its own power.

c. If it is urgently necessary to move a casualty and provided the ground is firm enough to prevent the roadwheels from sinking, the quickest method of making the vehicle mobile is to remove the track completely. This method can be employed in cases of a damaged front idler, a damaged suspension assembly and a damaged final drive.

d. Should a suspension unit be seized, the road wheels must be removed and the axle arms chained up well clear of the ground to prevent them fouling during the tow. With a damaged final drive, the coupling to the gear box must be disconnected.

2. DAMAGED FINAL DRIVE OR NO 3 SUSPENSION ASSEMBLY

a. In this case the vehicle cannot be made to move under its own power without changing the damaged assembly or assemblies. In emergency, when complete removal of the track might cause sinking, the tank can be towed by shortening the track so as to by-pass both assemblies. Referring to Figure 1 the detailed procedure is to:

(1) remove the road wheels from the front axle of No 3 suspension assembly and the side armour brackets between No 2 and 3 suspension assemblies;

(2) chain the forward axle arm of No 3 suspension assembly clear of the ground;

(3) take off all track adjustment and break the track between No 2 and 3 suspension assemblies on the ground run;

(4) count forward 76 links from where the track has been broken and break the track, removing surplus tracks from the rear end of the tank;

(5) pass the top loose end of the track over No 3 top idler wheel down between No 2 and 3 suspension assemblies;

(6) re-make the track and adjust so that approximately a three-inch sag is obtained between No 1 and 2 top rollers;

(7) disconnect the shaft between final drive and gearbox in cases where the final drive is damaged.

3. DAMAGED FRONT IDLER OR NO 1 SUSPENSION ASSEMBLY

a. Provided the final drive is intact and the No 2 and 3 suspension units are serviceable the vehicle can, in this case, be prepared to move

under its own power without changing the damaged assemblies. In emergency therefore, when complete removal of the track might cause sinking, the front idler and the No 1 suspension assembly are both by-passed. Referring again to Figure 1, the procedure is to:

(1) break the track between No 1 and 2 suspension assemblies on the ground run and remove the side armour bracket between No 1 and 2 suspension assemblies;

(2) count back 72 links from where the track has been broken, and break the track a second time and remove the shorter length;

(3) pass the end of the remaining track down in front of No 2 top roller and between No 1 and 2 suspensions and remake the track;

(4) remove the road wheels and chain the axle arms clear of the ground if the road wheel bearings are seized on No 1 suspension unit.

b. The vehicle can then be driven under its own power at slow speed. Care must be taken when driving with a shortened track as the steering does not fully respond.

4. DAMAGED NO 2 SUSPENSION ASSEMBLY

If No 2 suspension assembly is damaged and, for example, the road wheels are seized on the axles, the road wheels can be removed, the axles chained up clear of the tracks and if the other suspension assemblies are undamaged the vehicle can proceed over firm smooth ground under its own power at slow speed. The danger in this procedure is that over bumps the track will flex upwards and foul the axle arms even if they are chained up as high as possible.

NOTE

The foregoing instructions should be read in conjunction with EME Manual Vehicles J 289 Instruction 18.

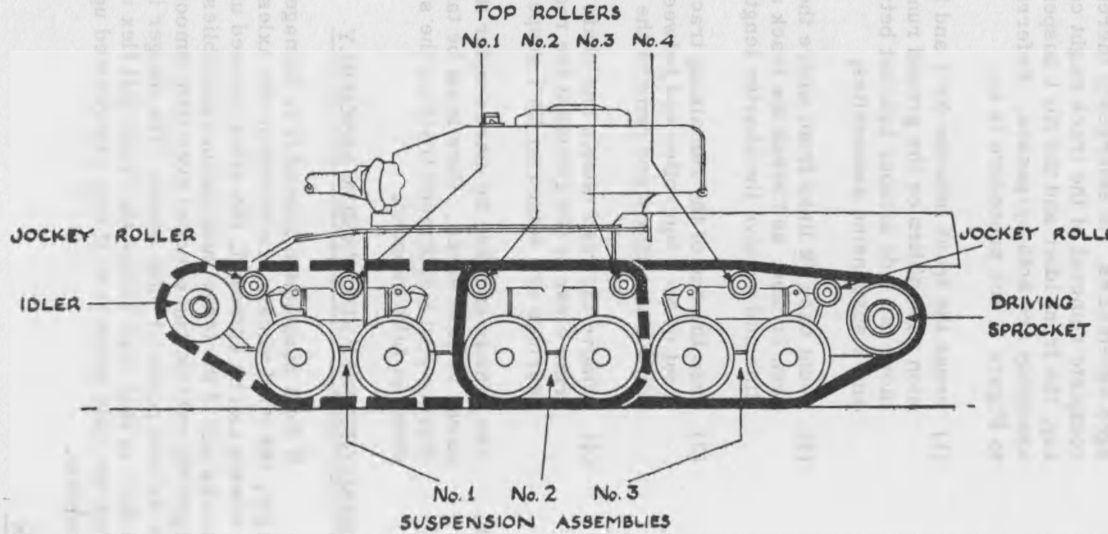


Figure 1 - Shortening track on Centurion tank

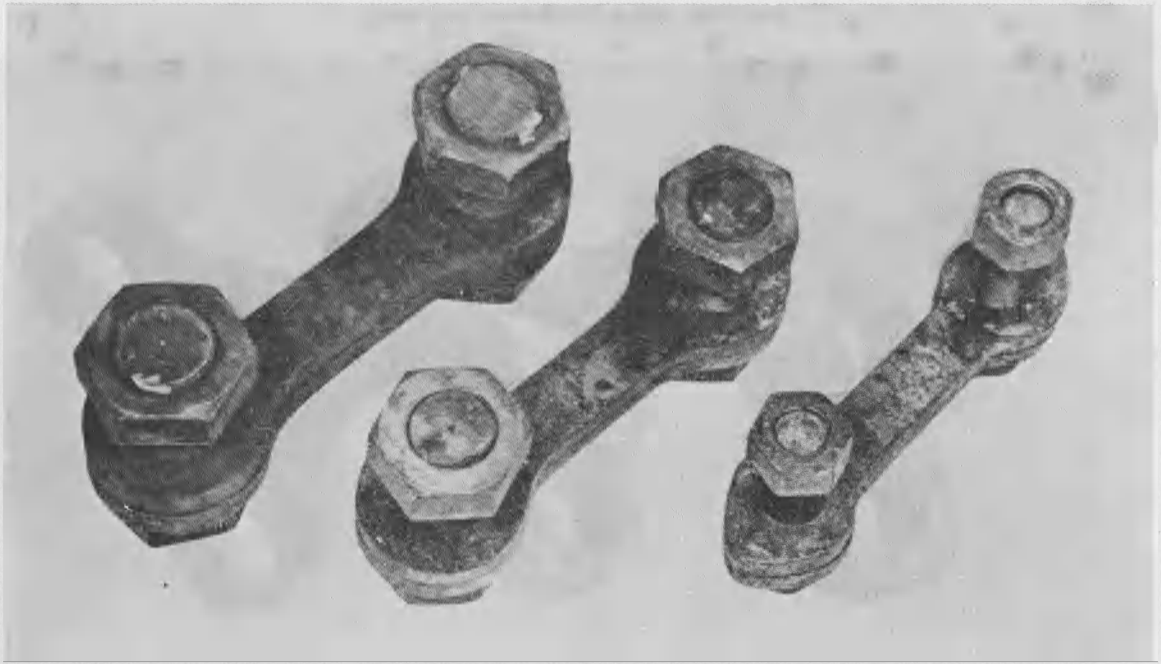


Plate 1 - Plate Shackles

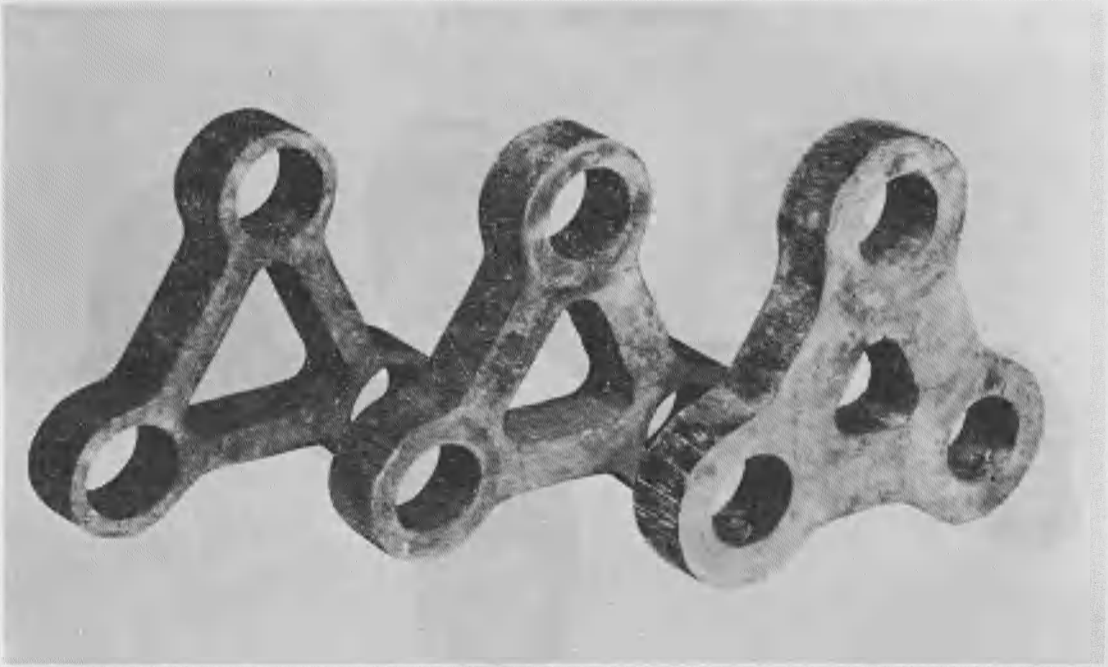


Plate 2 - Triangular Plate Shackles

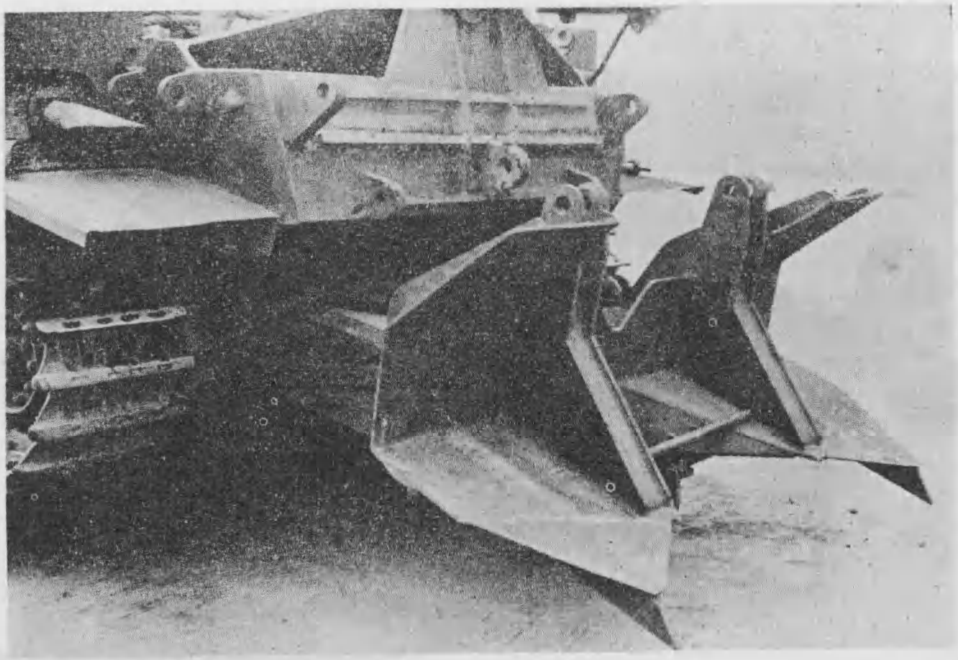


Plate 3 - Spade Anchor

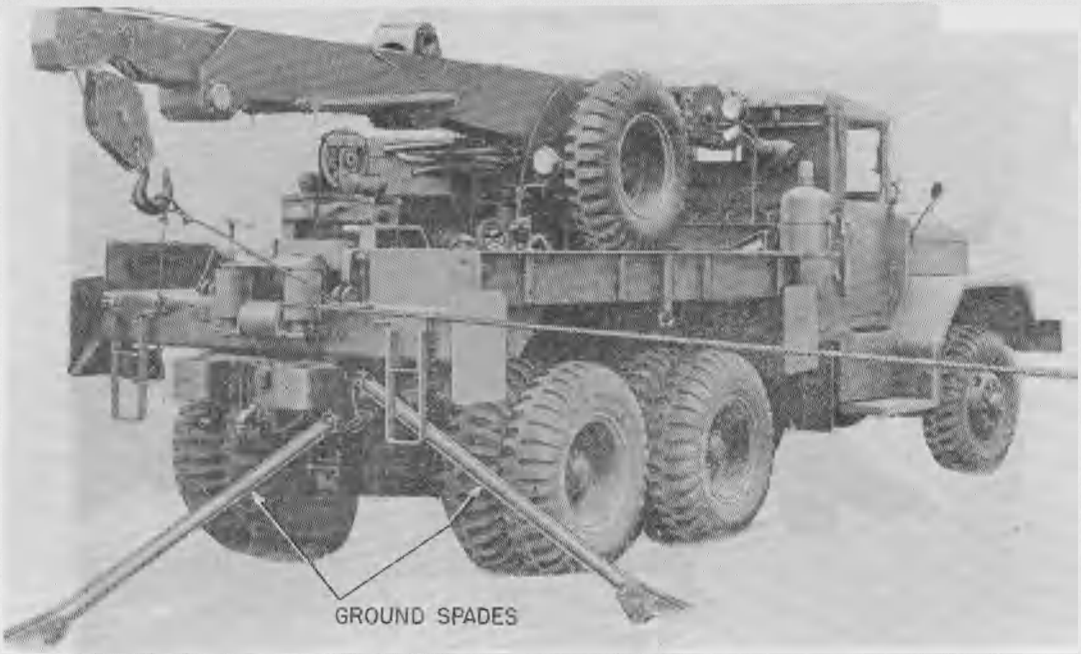


Plate 4 - Ground Spades

Plate 5 - Centurion ARV Mk 2

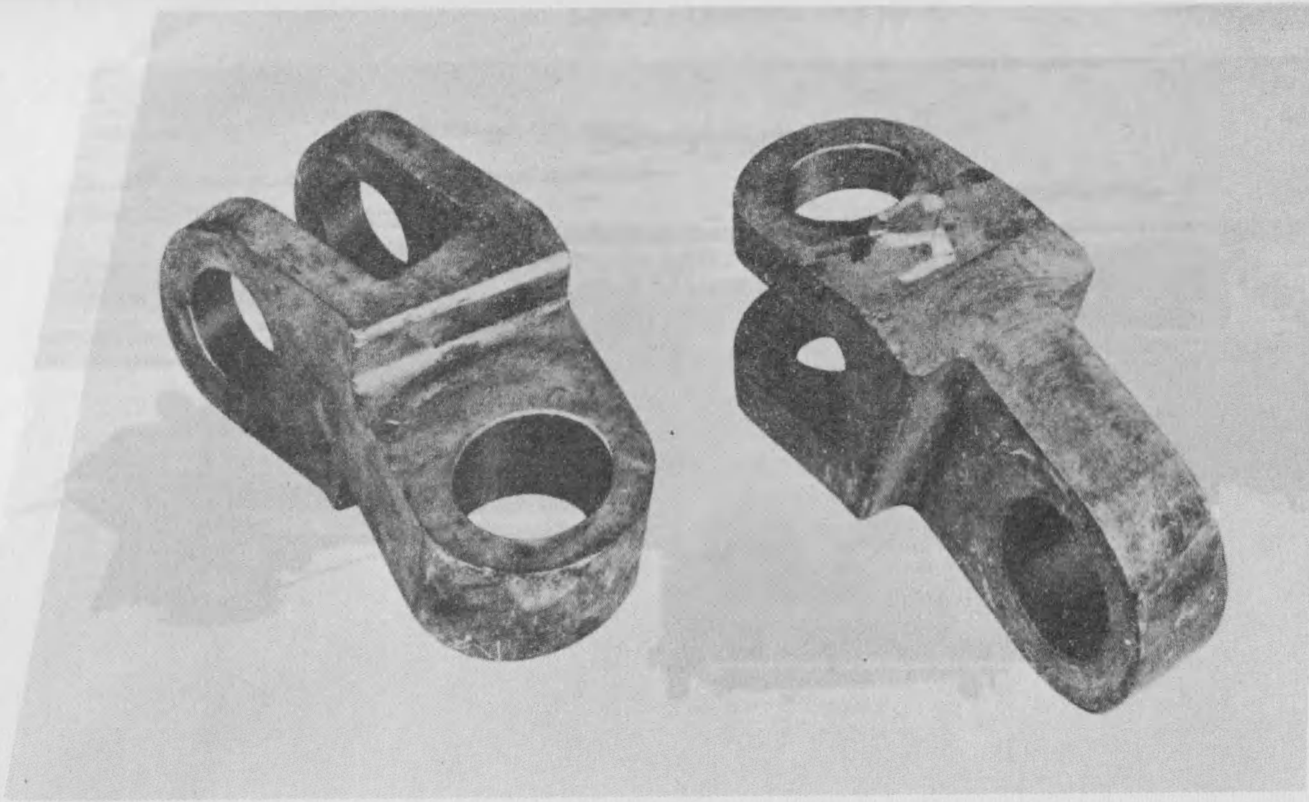


Plate 6 - Draw-bar Adaptors

Plate 7 - Belly-pull Applied to a Tank

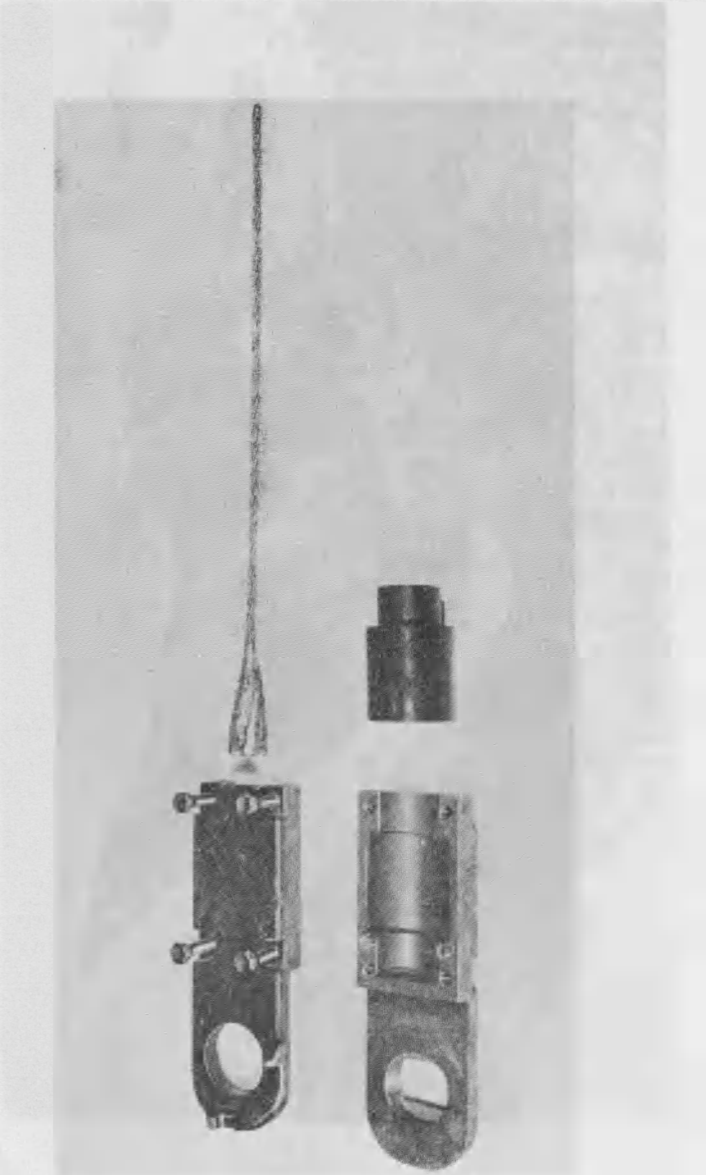


Plate 8 - Socket Adaptor

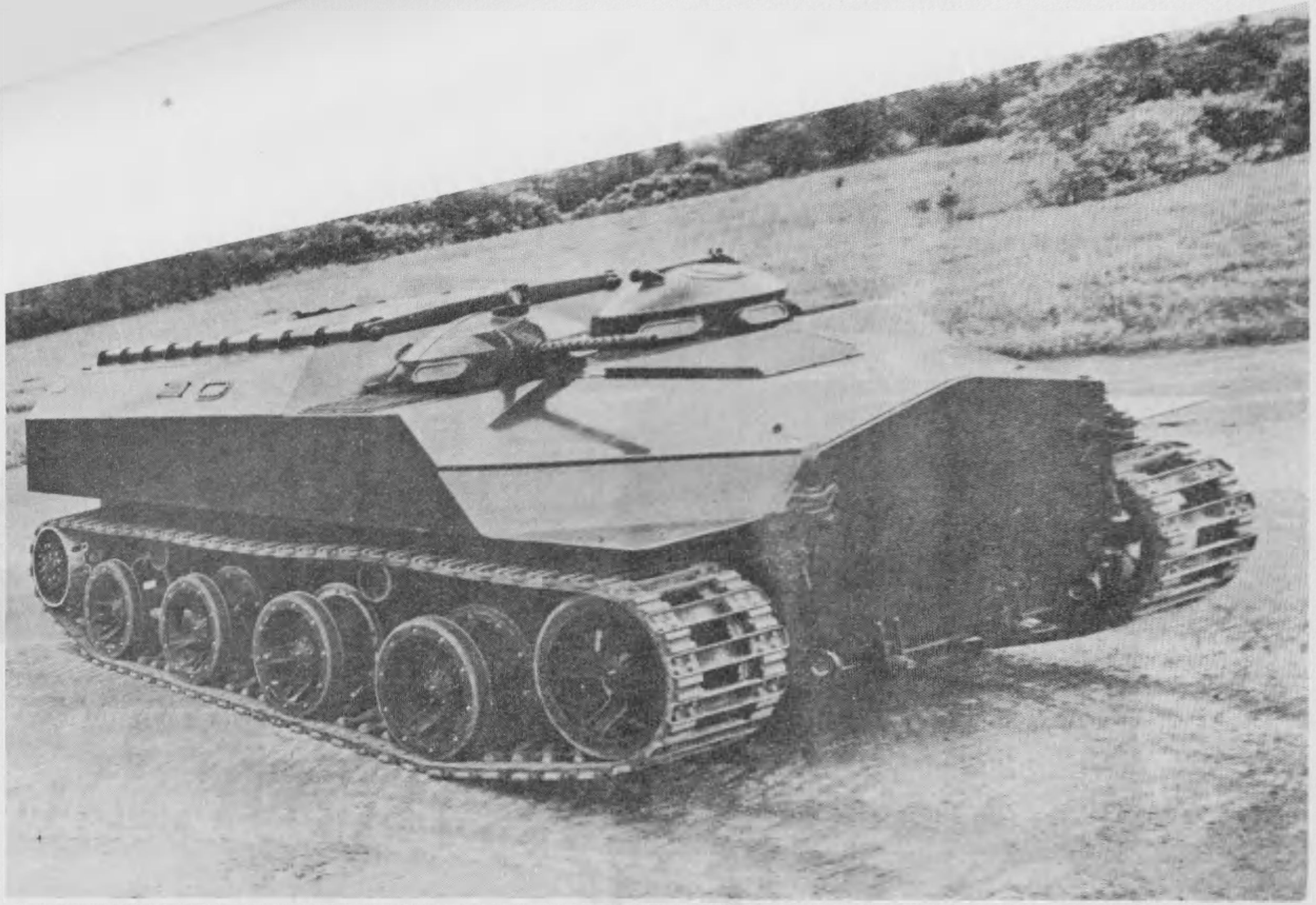


Plate 9 - Canadian Armoured Tracked Carrier

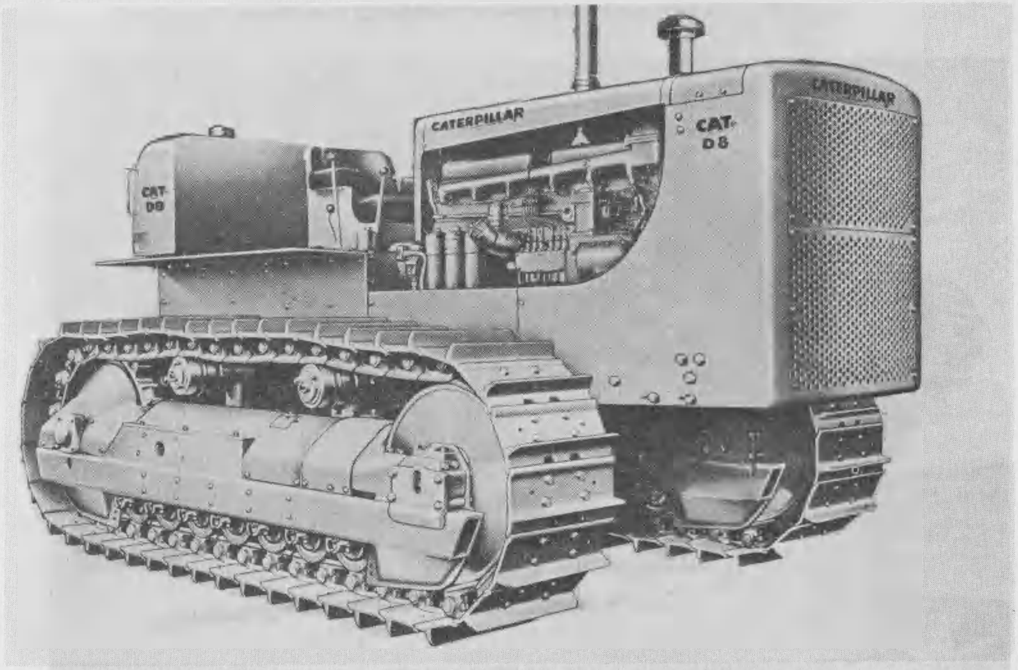


Plate 10 - Caterpillar D8

TABLE 1—BREAKING LOADS FOR STEEL WIRE ROPES OF 6-STRAND CONSTRUCTION

Nominal diameter (inches)	Approx weight (lbs/100 ft)	Breaking loads (tons)			
		Best Patent 80-90 tons/sq in	*Special Improved Patent* 90-100 tons/sq in	*Best Plough* 100-110 tons/sq in	*Special Improved Plough* 110-120 tons/sq in
Part 1—Round strand wire ropes, 6/6 or 6/7 construction					
½	47	8·4	9·4	10·5	11·4
⅝	72	13·0	14·6	16·2	17·7
¾	97	18·3	20·4	22·6	24·8
13/16	107	20·1	22·5	24·8	27·2
⅞	132	24·9	27·8	30·7	33·7
15/16	154	29·1	32·6	36·0	39·4
1	168	31·3	35·0	38·7	42·4
1⅛	217	39·8	44·5	49·3	53·9
1¼	262	48·6	54·3	60·1	65·8
Part 2—Round strand wire ropes, 6/19 construction					
½	43	7·2	8·1	9·0	9·9
⅝	66	11·1	12·4	13·7	15·0
¾	92	15·7	17·6	19·4	21·3
13/16	102	17·0	19·1	21·1	23·1
⅞	123	20·5	22·9	25·3	27·7
15/16	154	25·8	28·9	31·9	34·9
1	168	27·5	30·7	33·9	37·2
1⅛	217	35·5	39·6	43·8	48·0
1¼	262	43·5	48·6	53·7	58·8
Part 3—Flexible round strand wire ropes, 6/37 construction					
½	43	6·8	7·9	8·4	9·2
⅝	66	10·7	11·9	13·2	14·4
¾	92	14·5	16·2	18·0	19·7
13/16	102	16·2	18·1	20·1	22·0
⅞	123	19·9	22·3	24·7	27·0
15/16	145	24·1	26·9	29·8	32·6
1	159	26·2	29·4	32·4	35·5
1⅛	198	32·2	36·0	39·7	43·5
1¼	242	40·0	44·7	49·4	54·1
1⅝	409	66·9	74·7	82·6	90·5

TABLE 2—MINIMUM DIAMETERS OF WINCH DRUMS AND SHEAVES FOR STEEL WIRE ROPES

Diameter of rope (inches)	Minimum diameter (inches)		
	6/12 construction	6/19 construction	6/37 construction
½	9	11	8
⅝	12	15	10½
¾	13½	16½	12
13/16	15	18	13
⅞	16½	20	14½
15/16	18	22	16
1	20	24	17
1⅛	21	25½	18½
1¼	22½	27½	20

TABLE 3 - SAFE WORKING LOAD OF CORDAGE BLOCKS

Size of Fibre Rope	Type of Block	Safe Working Load
3/8 inch	single	200 lbs
1/2 inch	single	400 lbs
1/2 inch	double	550 lbs
1/2 inch	triple	700 lbs
5/8 inch	single	500 lbs
5/8 inch	double	750 lbs
5/8 inch	triple	1000 lbs
3/4 inch	single	1500 lbs
3/4 inch	double	2000 lbs
3/4 inch	triple	2500 lbs
1 inch	single	1700 lbs
1 inch	double	2450 lbs
1 inch	triple	3200 lbs
1 inch	snatch	5000 lbs
1 1/4 inch	double	3750 lbs
1 1/2 inch	single	3600 lbs
1 1/2 inch	double	4800 lbs
1 1/2 inch	triple	6000 lbs
1 1/2 inch	snatch	10000 lbs

TABLE 4 - SAFE WORKING LOAD OF WIRE ROPE BLOCKS

Size of Wire Rope	Type of Block	Safe Working Load
3/8 inch	double	4000 lbs
3/8 inch	triple	5000 lbs
1/2 inch	single	4000 lbs
1/2 inch	double	5000 lbs
1/2 inch	triple	6000 lbs
1/2 inch	snatch (3/4 in centre pin)	3000 lbs
1/2 inch	snatch (1 1/4 in centre pin)	14000 lbs
1/2 inch	snatch (7/8 in centre pin)	5000 lbs
5/8 inch	single	5000 lbs
5/8 inch	double	6000 lbs
5/8 inch	triple	7000 lbs
5/8 inch	snatch	7000 lbs
3/4 inch	single	9000 lbs
3/4 inch	snatch (1 1/4 in centre pin)	8000 lbs
3/4 inch	snatch (2 1/4 in centre pin)	24000 lbs
1 inch	single	15000 lbs
1 inch	double	18000 lbs
1 inch	triple	22000 lbs
1 inch	snatch	16000 lbs